Together for Science and Conservation

WMMC'19
World Marine Mammal Conference
Barcelona 2019

BOOK OF ABSTRACTS

WORKSHOPS // DECEMBER 7-8, 2019
MAIN CONFERENCE // DECEMBER 9-12, 2019

Centre de Convencions Internacional de Barcelona
Barcelona, Catalonia, Spain

OUR HOLA!

This adventure began in 2015 when the Society for Marine Mammalogy and the European Cetacean Society decided to join forces to host a World Conference. Barcelona was chosen by membership vote that year as the venue for the conference, to be co-organized by SUBMON and the University of Barcelona.

The World Marine Mammal Conference was full of new and exciting research! We were delighted to welcome a community of over 2700 people from 95 countries involved in marine mammal science and conservation, who shared an intense and rewarding week at the WMMC'19. There will be three global plenary sessions, 627 talks and 1077 posters that presented cutting-edge and thought-provoking research that will help lay the foundation for our work into the future.

A total of 1,952 abstracts were submitted for WMMC'19; however, the Program schedule allowed for only 1,652 abstracts to be presented. A panel of 451 experts (listed below) volunteered their time to review and score abstracts on a scale of 1 to 5 for criteria of originality, quality, importance, and presentation. In an effort to minimize reviewer bias, all authors and affiliations were removed from the abstracts before review. Most abstracts were reviewed by 3 experts.

After normalizing scores to correct for inter-reviewer variability, abstracts were ranked on the basis of overall score. Authors of the highest-scoring abstracts were given their first preference for presentation, whether poster, speed, or oral. Given this rigorous process and the excellence of the abstracts selected for the conference, we are confident the quality of work presented at this meeting will be unparalleled.

In closing, we wish to thank the magnificent group of very passionate and committed people who have voluntarily worked hard over the last two years to create the best program for the WMMC. Please see the very long list of these fine individuals on the next page!

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The European Cetacean Society (ECS) was established in January 1987 and aims to promote and advance the scientific studies and conservation efforts of marine mammals and to gather and disseminate information about them to members of the Society and the public at large. The ECS is coordinated by a Council of 11 members and each year organizes an Annual Conferences in a European country.

THE SOCIETY FOR MARINE MAMMALOGY

The mission of the Society for Marine Mammalogy (SMM) is to promote the global advancement of marine mammal science and contribute to its relevance and impact in education, conservation and management.

CONFERENCE ORGANIZERS

SUBMON is a marine environmental organization born in 2008 with the aim to conserve, study and educate about the marine environment. It works to preserve marine biodiversity and to reach a sustainable use of the marine environment through promoting a change in the relationship between society and the ocean, conducting in situ actions and sharing knowledge. Its core team has more than 20 years of experience working with marine mammals, sea turtles, sharks and marine habitats. SUBMON is part of the Marine Mammal Expert Group for the implementation of the EU Marine Strategy Framework Directive and of the National Underwater Noise Expert Group.

Founded in 1450, the University of Barcelona is the major public university in Catalonia and the only Spanish university member of the League of European Research Universities (LERU). According to the Center for World University Rankings (CWUR), the UB is listed among the top 100 universities worldwide, and according to The Times Higher Education, the University of Barcelona is listed among the top 25 universities with more than 400 years of history. As WMMC19 Co-organizator, the Large Marine Vertebrates Research Group of the University of Barcelona focuses its research activities on conservation-related aspects of the biology and ecology of large marine vertebrates and its activity spans four main lines of action: conservation-oriented research, training of researchers and technicians, technical implementation of specific actions of conservation, and public awareness on the environmental challenges affecting large marine vertebrates.

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This conference would not have been possible without the hard work and dedication from our conference committees and volunteers!

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WMMC'19 ABSTRACTS:
ORAL, SPEEDTALKS AND POSTER PRESENTATIONS

The following is a list of all accepted abstracts for oral, speedtalks and poster presentations that were presented at WMMC'19. They are in alphebetical order based on the first author.

Marine stewardship strategy as conservation tool of common bottlenose dolphin (Tursiops truncatus) population in the Cap de Creus Canyon MPA, North-western Mediterranean basin: Habitat use and fishery interaction.

A. Chicote, Carla[1]; Auladell Quintana, Clàudia; Álvarez de Quevedo, Irene[1]; Gazo, Manel[2]
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Populations of Common Bottlenose dolphins (CBD) (*Tursiops truncatus*) have a very wide distribution in the Mediterranean Sea, although, most of the studies has been conducted in the northern part. It is more abundant in coastal waters above the continental shelf and the habitat use is extremely related with feeding behavior and diet preferences and depends on prey availability and specific conditions in each area. Total abundance for the Mediterranean Sea Common Bottlenose Dolphin subpopulation, listed as Vulnerable on the IUCN Red List, is unknown but thought to be in the low 10,000's and decreasing. The present study shows the results of a marine stewardship strategy implemented as a conservation tool within the Sites of Community Importance (EU-SCIs) of Cap de Creus and Lacaze-Duthiers area and the Natural Park of Cap de Creus MPA. The main objective was to determine habitat use and asses fishing interaction impact on a CBD population in the study area. A two-year based photo-id monitoring program was started in 2017. Visual transects and photo-identification surveys were conducted on the MPA using a 6 meter long RIB. A total of 3112 nm of effective effort was carried out with a total of 48 CBD sightings. Model prediction of occurrence probability has been implemented showing that distribution is related with depth and that there are two important areas of presence for the CBD population. Besides, most of CBD sightings (64%) were associated with trawl-fishing activities suggesting an dolphin-trawling interaction. stressing the need for further research to better determine the impact of the activity on the population and vice versa. With the aim of a bottom-up approach to minimize this interaction a marine governance strategy is being implemented among fishermen community in order to establish conservation measures such a ecolabel for best practices fish products when best practices of fishing are used.

Reproduction and survival of Svalbard polar bears

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Capture-recapture data is frequently used to gain estimates on reproduction and survival of wild animal populations. Frequently, these estimates may be biased, e.g. when capture probability varies with life history stages. Among polar bears in Svalbard, live capture is opportunistic, and areas are not covered evenly. Many bears travel between Svalbard and Russian Arctic, and distribution of female bears that have been denning and are with cubs in spring will to a large degree depend on which maternity denning areas were available in fall the year before. For bears to reach denning areas, the actual islands need to be connected to hunting areas by sea ice. Proportions of females with cubs captured may thus not be representative of the population.

Capture data provides information on reproduction (presence or absence of cubs) and survival up to the capture date. Satellite telemetry data provides data also in the period after, up to several years. The signature of the data reveal if a bear is alive, and also if she is reproducing (as only females giving birth stay in dens for prolonged periods in winter). We employed from 10-20 collars the last 15 years on adult females, most working more than a year. From 2011, we also employed small data loggers in one ear on each female captured (geolocation tags, Migrate Technology). These tags have a battery life from 5-10 years. Most years, we have recovered 10-20 tags upon recapture, with one to several years of data. Light and temperature reveal maternity denning events, and thus a combination of data from collars and ear tags made it possible for us to construct denning (reproduction) and survival history of many females, and compare estimates with those from capture-recapture data. Results show a high frequency of failed breeding, or early loss of cubs.

Strandings of Longman's beaked whale (Indopacetus pacificus) in the Philippines

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Longman's beaked whale, *Indopacetus pacificus*, is one of the least known of all cetacean species. Its

external appearance was only first described in the 21st century. Prior to 2004, the species was known from only six specimens. Although at least twenty more specimens were recovered from strandings since then, knowledge on the species is still very limited. In the Philippines, the first record of the species was confirmed through a stranding in Davao in 2004. Sightings of *Indopacetus pacificus* alive at sea in the Philippines remain unconfirmed. Herein we account for all the strandings of the species in the Philippines and describe the specimens collected and their status based on examined stranding reports and actual examination of the specimens conducted by one or more co-authors. To date, there are four confirmed strandings of the species, all sub-adult individuals, which occurred at four different sites: 1.) 5.73m male at Matina-Aplaya, Davao in 2004; 2.) 5.02m male at General Nakar, Quezon in 2016; 3.) 5.4m male at Gonzaga and 4.) 5.6m male at Sta. Ana, both in Cagayan Province in 2018. Three of the strandings occurred at northern Luzon, while one in southern Mindanao. Two out of four stranded alive but died shortly after. From three of these the skeleton, stomach contents and tissue samples were examined and collected. Squid beaks and lenses were found in the stomach. Skin samples are pending genetic analysis. The skeletal specimen collected from Sta. Ana, Cagayan is by far the most complete in the country and is probably in one of the best conditions in the world. For a cetacean species that is poorly known examination of stranded specimens offers a rare opportunity to collect information. Hence, the importance of standardizing necropsy and stranding data collection protocols, training stranding first-responders and establishing a database are emphasized.

Do bigger bodies require bigger radiators? Insights into thermal ecology from closely related marine mammal species and implications for ecogeographic rules.

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Ecogeographic rules, which aim to describe latitudinal variation in morphology within and between species, have seldom been examined in marine mammals. Bergmann's and Allen's rules, based upon thermoregulatory concepts for terrestrial mammals, describe an increase in body size [and concomitant decrease in surface area to volume (SA:V)] and decrease in appendage size (decrease in SA) with latitude. However, the unique thermoregulatory challenges of life in an aquatic environment may result in alterations or exceptions to these rules in marine mammals. Short- and long-finned pilot whales (*Globicephala macrorhynchus* and *G. melas*, respectively) provide an ideal opportunity to examine these ecogeographic rules in marine mammals because of their contrasting latitudinal distributions, morphological differences, and associations with varying temperature regimes. We applied 3D models, scaled using morphometric data from stranding networks, to examine interspecific differences in core body SA:V and appendage SA normalized by total length (SA:TL). In addition, we examined intraspecific trends between core body heat retention and appendage heat dissipation. Interspecific differences in body size supported Bergmann's rule: the more temperate long-finned pilot whale had a larger body size and lower core body SA:V than the more warm-water short-finned pilot whale. However, Allen's rule was not supported; long-finned pilot whales had larger overall appendage SA:TL than short-finned pilot whales. In addition, for both species we observed a strong and highly significant negative relationship between SA:V (heat conservation) and appendage SA (heat dissipation). Marine mammals have thinly insulated appendages that can be used to dissipate heat as the core warms. We found that both within and between species, the low overall SA:V of larger individuals was apparently balanced by a larger surface area of appendages over which to dissipate heat. Our results provide novel insight into ecogeographic rules and suggest that thermoregulatory adaptations have profound effects on morphological patterns in marine mammals.

Vessel activity trends in the Arctic, 2015-2018

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Arctic systems are among the most rapidly-changing on the globe. The increase in the extent and duration of seasonal ice-free waters is creating new opportunities for high-latitude maritime trade and marine resource utilization activities in historically inaccessible areas such as the Northern Sea Route and Northwest Passage. Associated degradation of Arctic marine ecosystems may accompany growing vessel operations through elevated levels of underwater noise, air-borne emissions, and introduction of non-native species. In addition, potential for large oil spills, among other things; and may compound stressors already

effecting biological populations as a result of climate change. Therefore, ongoing Arctic-wide, multi-year assessments of vessel traffic are needed. We analyzed 2015-2018 global satellite Automatic Information System vessel data to quantify the existing volume and spatial distribution of vessel operations, assess possible changes in these operations, and establish a baseline for ongoing monitoring. Several metrics, including hours of operation, amount of sea surface exposed to vessel traffic, and number of trips, were used to assess operations. Maritime activities in the Arctic (an area defined by the Arctic Research and Policy Act) were extensive and diverse. Fishing vessels accounted for nearly 50% of the total transits each year. Inter-year fluctuations in different locations throughout the region complicate the identification of simple, single-factor explanations (e.g., ice cover levels) regarding trends. Instead, variables such as abundance and distribution of fisheries resources, market forces (*e.g.*, global oil/gas demand), and economic feasibility as weighed against inherent risks of high Arctic marine travel appeared to influence regional activities. While measures (e.g., the Polar Code) have been established to protect Arctic marine ecosystems from vessel activities, the potential risks associated with expanding commercial and industrial activities in the region will likely warrant their expansion.

Bioenergetic requirements of grey whales in the face of prey shortages

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Eastern North Pacific grey whales (*Eschrichtius robustus*) rely heavily on energy reserves obtained on their northern feeding grounds to complete their annual 17,000 km round trip between the Arctic and Mexico. Unusually high mortalities of grey whales observed in 1999 and 2000 during their northward migration were attributed to starvation caused by reduced prey availability (likely due to climate change) or competition from increased numbers of whales on the feeding grounds. However, the role that decreased prey intake had on the observed mortalities cannot be evaluated without knowing the minimum amounts of prey required to sustain the annual migration. We addressed this knowledge gap by constructing an age-structured bioenergetics model to predict the energy requirements of each migrating cohort of grey whales and estimated the minimum threshold of daily prey consumption needed during the summer to avoid nutritional stress during the annual migration. Inputs included a comprehensive growth model describing mass-at-age for females and males, and refined estimates of energetic expenditure for different activity states based on field measurements of respiration rates at each life stage or reproductive state. Our model thereby derived daily food requirements (e.g., kg of amphipods, mysid shrimp, etc.) for all age classes of grey whales and also incorporated a range of annual energetic requirement thresholds that has specific life history consequences. Thus, we related death and reproductive failure to the amounts of prey consumed (i.e., expressed as a proportion of daily energy requirements met) to predict future mortality rates of grey whales as a function of varying prey densities. Our results, when combined with measured densities of benthic prey, can be used to assess and anticipate the likelihood of starvation-related mortality events occurring, due to either population or environmental changes.

Population parameters of southern right whales (Eubalaena australis) off Península Valdés, Argentina, for the period 1971-2015

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Long-term studies can generate key information on the life histories and dynamics of wild populations. Southern right whales at Península Valdés, Argentina, have been monitored since 1971 through aerial photographic surveys. A 45-year dataset (1971–2015) of individuals life histories was used to estimate apparent survival, capture probability, abundance and population growth rate using capture-recapture methods. A total of 8951 sightings were used to create a photo-identification-based encounter history for 3487 individuals identified in the sampling area: 1319 females, 98 males and 2070 individuals of unknown sex. Of all individuals identified, 37.5% (n=1307) were re-

sighted over subsequent years and 21.3% (n=742) were identified in their year of birth. The Cormark-Jolly-Seber models estimated a constant apparent sex-specific survival of 0.995 (95% CI 0.993–0.997) for females and 0.951 (95% CI 0.938–0.961) for males. The recapture probabilities were not affected by variation in the survey effort but differed between adults and newborns and were time-dependent. The POPAN super-population approach estimated a varied abundance from 615 (CI 504-752) in 1980 to 4669 (CI 4176–5226) in 2014, totalizing 9197 (IC 8548–9898) different whales present in the population between 1971 and 2015. The Pradel formulation approach estimated constant population growth of 5.6% (IC 5.3–5.9) for the period 1971-2015, similar to the estimates from theoretical models previously developed for this population. In the early years (1975–1985), resightings were higher than the sightings of new whales (32.1%), however, in the last decade (2005–2015), 59.8% of the sightings corresponded to new whales (n= 1323). Southern right whales at Península Valdés have experienced high calf mortality events since 2003. Considering Península Valdés as the largest calving ground in the Western South Atlantic Ocean, these estimates are essential when assessing the conservation status of this whale population.

Fear of killer whale predation drives extreme collective behaviour in beaked whales

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Fear of predation risk is a strong evolutionary pressure for prey species. Here we use animal borne DTAGs to investigate the evolution of anti-predatory behaviour in beaked whales for which fear of predation drives mass mortalities related to naval sonar exposure. Beaked whales play a predator-prey arms race against killer whales mediated by acoustic detection of prey and predators. Here, beaked whales are obligated vocalisers, as they need to use echolocation to forage at 200-3000 m depth. In contrast, killer whales reduce acoustic emission when hunting mammals sensitive to the frequencies of their calls, meaning that beaked whales need to be alert at all times, as they can be unaware of the presence of killer whales. We show that groups of Cuvier´s and Blainville´s beaked whales reduce to <25% their temporal availability for acoustic detection by killer whales thanks to closely coordinated diving and vocal behaviour. Their extreme synchronicity is not for cooperative foraging as group members spread at depth to hunt. This foraging footprint and their long dives limit their group size and metabolism, reducing their defences from predators. Instead, beaked whales resort to acoustic hiding to minimise predator encounter rate: full groups diving in synchrony are free to ascend silently in a random direction from deep dives, covering >1 km horizontal distance. These long ascents have physiological and foraging costs, but reduce by an order of magnitude the risk of post-detection interception by stalking killer whales. The idiosyncratic behaviour of beaked whales has enabled them to thrive in most oceans by exploiting a specialised deep water niche while reducing predation from killer whales. However, this fear-driven behaviour turns maladaptive when beaked whales are confronted with novel predator-like human stimuli such as sonar.

Wetlands sedimentation as a major threat to manatee survival: An analysis of Antillean manatee stranding cases in the Magdalena River (Colombia).

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Antillean manatees (Trichechus manatus manatus) are considered Endangered. In Colombia the threats to the species include hunting, entanglement, and habitat loss. Particularly, the rapid increase of wetlands sedimentation in the Magdalena River Basin (MRB) could represent a major risk factor during the dry season. We reviewed social media and newspapers to obtain information of incidents involving manatees in the MRB, occurring between 2014 and 2019. For each event, we gathered information on date, locality, size, sex, and probable cause of death. We compiled 49 records of stranded manatees along the Middle (24.4%) and Lower (75.5%) Magdalena River (30.6% females; 24.4% males; 44.8% unknown), with 85.7% of casualties occurring during the dry season. In 27 cases the manatee was found dead, and the causes of decease were poaching (7.4%), stranding

(11.1%), killed after stranding alive (37.0%), perinatal (animals that were less than 150 cm in total length that did not die from human related causes) (3.7%) and unknown (29.6%). Twenty-two manatees were found alive and either relocated (63.6%) or released in situ (36.3%). Our records indicate that dry season represents the time of highest vulnerability and signal the sedimentation as a major threat for manatees. The MRB have undergone dramatic changes in land cover and further forest loss during the last three decades, causing an increasing sedimentation and a significant reduction of the water column of floodplain lakes and associated wetlands. Manatees in the MRB migrate forced by pronounced seasonal hydrologic fluctuations. Their migratory routes encompass shallower segments, some of which dry out during the most lowering-water seasons due to sedimentation, blocking the passage to refuge areas and increasing the chances of isolation, stranding, vulnerability to illegal hunters, and/or death. An effective strategy for protecting manatees will require socioecologic and community-based conservation approaches, which guarantee the preservation at a landscape scale.

"I don't want to go Mrs. Mom"… Survival rates for mothers and calves in common bottlenose dolphins from the southwestern Gulf of Mexico.

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Demographic parameters are hard to estimate in many cetaceans, due to their large home ranges and population sizes; furthermore, they are exposed to natural selective pressures and anthropogenic impacts, which consequently influence their mortality. Negative effects may be reflected on top predators, such as the common bottlenose dolphin, as it faces natural and artificial alterations in their ecosystem. The coastal waters off Alvarado in Veracruz, Mexico, sustains a highly productivite artisanal fishery, which competes with dolphins for common food resources. Thus, we estimated the (apparent) survival rate for mothers and their calves using mark-recovery information from 98 dorsal fin photo-id surveys (2002-2010) using the Cormack-Jolly-Serber model. We used individual records on 28 well-known females (678 records) and their calves (589 records for the first and up the third calf). We also estimated the nursing period through a half-weight coefficient of association (COA) in SocProg. Mothers' survival was 0.99 ±0.14 s.d., and we found slight differences in average calf survival depending on their birth order (first 0.74±0.53; second 0.83±0.46; there was not enough reliable data for the third calf). Also, mother-calf COA values showed a monotonical decrease, which was not different from the null model at 2.9 years, and thus was assumed as the nursing period. Mother survival is within the reported values for the species, and the higher (apparent) mortality rate for calves may involve both natural (predation) and anthropic causes related to direct (wounds and entanglements) or indirect (stress and lower feeding opportunities) interactions. The difference between survival rates of the first and second calf may suggest a learning process for the mothers. Finally, the estimated nursing period is on the lower limit for the species, suggesting earlier independence for calves inhabiting this area, probably derived from competition for food resources.

Blubber cortisol concentrations as a bioindicator of stress response and overall health status in stranded striped dolphins (Stenella coeruleoalba)

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There is a growing concern about the impacts of environmental changes and anthropogenic threats in marine mammals. In recent years, efforts have been directed to understand how marine mammals cope with stressors and to validate stress biomarkers, mainly through analysis of glucocorticoid hormones (e.g. cortisol). In this study, we correlated blubber and serum cortisol levels in response to cause of death in striped dolphins (*Stenella coeruleoalba*). Samples were obtained post-mortem from 52 individuals stranded on the Mediterranean coast between 2012 and 2018. A steroid hormone extraction method was performed and cortisol was analysed by enzymeimmunoassay. Individuals were divided in two groups according the cause of death, which was determined through veterinary necropsies and anatomopathologic studies: (1) Stranding,

including alive and dead stranded animals which were euthanized or died due to a disease or condition that impeded survival; and (2) Bycatch, i.e. dead stranded animals suspected to be discarded by fishermen after being incidentally captured. Cortisol concentrations (mean ± SD) were six times higher in stranded animals (35.3 ± 23 ng cortisol/g blubber; 66.3 ± 32.2 mg cortisol/ml serum) compared to the bycaught group (6.2 ± 4.3 ng cortisol/g blubber; 11.5 ± 15.1 mg cortisol/ml serum). Further, high correlation was found between circulating and blubber cortisol concentrations ($R2 = 0.73$, $p < 0.01$), providing the first evidence of this relationship in free-ranging animals. Both serum and blubber cortisol concentrations appeared to reflect a physiological state of chronic stress response in stranded striped dolphins. However, further research should address the kinetics of blubber cortisol incorporation and removal. The present study provides evidence that serum and blubber cortisol concentrations have the potential to be used as biomarkers of stress response in stranded striped dolphins, and of overall health status in free-ranging cetaceans. Moreover, it could have applicability in the study of cetacean stranding causes.

DNA collection from free-ranging Hector's dolphin and its environment

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Background:

Genetic sampling has been widely adapted for conservation and wildlife management. Obtaining DNA from free-ranging wild cetaceans is challenging, with collecting dart biopsies being commonly used. However, interest in less invasive methods has been arising, particularly when collecting from endangered species. Recent studies have shown that DNA can be collected using the exhaled air, or blow, of cetaceans. Furthermore, a study has demonstrated that species identification could be possible by collection of environmental DNA (eDNA). While larger Delphinidae (*Orcinus orca*) have had samples collected in this manner, we report here on the first DNA collection from blow in the small Hector's dolphin (*Cephalorhynchus hectori*).

Methodology/Principle findings:

In this study, we investigated if valid blow samples could be retrieved from the free-ranging Hector's dolphins in Kaikoura (New Zealand), one of the smallest cetacean species in the world. Seawater was also collected concurrently with the blow for eDNA analysis. Our methodology involves 62 blow samples that had been taken from Hector's dolphin, using petri dish on an extendable pole, and 32 water samples collected from the sea surface. To optimize detection, multiple displacement amplification, and purification steps were applied before PCR amplification of a Hector's dolphin specific mitochondrial sequence. Sanger sequencing of amplicons identified DNA from Hector's dolphins, from both the blow and the seawater samples.

Conclusions/Significance:

Here we show that the DNA were retrievable from the blow of wild dolphin, and the surrounding seawater. This study adds support that blow sampling and collection of eDNA are viable and less invasive genetic sampling methods. This study also indicates the possibility of the application of the blow sampling to any cetacean species, as the Hector's dolphin, being the one of the smallest of its order, potentially could demonstrate the lowest exhalation airflow rates.

Monitoring population trends of Baltic ringed seals in changing ice conditions

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The Baltic ringed seal (*Pusa hispida ssp. botnica*) is one of the five subspecies of strongly ice-dependent ringed seals. During early 1900's hunting and environmental contaminants caused a massive population decline from approximately 200 000 to only 5 000 individuals. Its breeding distribution is today limited to the Bothnian Bay and to small remnants further South.

Ringed seals primarily give birth in lairs which they dig in snow drifts on sea ice to protect their pups against harsh weather and predators. Their breeding success and breeding distribution is strongly associated with ice-conditions. Population monitoring of the ringed seals in Bothnian Bay is based on aerial line-transect methodology over ice

during moult in April. Surveys have been carried out on an annual basis since 1988, constituting a unique long-term data-set.

Here we show how the Baltic ringed seal population in Bothnian Bay, where sufficient ice-conditions have been common until recently, has increased by average rate of 5 %/year to a total population size of over 20 000 animals during 1988-2019. The more Southern stocks have been affected by poor ice-conditions in most years which have likely impeded their recovery. Today climate warming is also diminishing the extent and quality of the breeding habitat for the Baltic ringed seals in the Bothnian Bay.

During the ongoing decade, warm winters have even compromised the monitoring method. In years with limited extent and early breakup of sea-ice, the results have been exceptionally high, not comparable with the results from years with stable ice-conditions, possibly due to changes in seal behavior in response to sea-ice cover. With current projections of climate warming the future for the Baltic ringed seal population is uncertain and the population development may be hard to follow since the quality of the population monitoring will be jeopardized.

Inter-annual variability in acoustic detection of blue (Balaenoptera musculus) and fin whale (B. physalus) 20 Hz calls in the Northeast Atlantic High Arctic.

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Blue whales and fin whales are regular seasonal migrants to the High Arctic. They are thought to feed throughout the summer months, taking advantage of the intense pulse of summer productivity in the High North, before returning to temperate areas at lower latitudes for the winter. Trends in distribution and habitat use of these species are not well known in the Northeast Atlantic but given that the Arctic is undergoing profound changes in sea ice dynamics associated with global warming a change in habitat use and movement behaviour of these migrating species is predicted. In this study, passive acoustic monitoring was used to investigate the spatial and temporal occurrence of these species in the Northeast Atlantic sector of the High Arctic. Two AURAL recorders were deployed on oceanographic moorings, one in the Fram Strait at about 79˚N and another situated north of the Svalbard Archipelago at about 81˚N (ATWAIN). Acoustic data were available for seven years for Fram Strait (in the period 2008-2018), and three years for Atwain (in the period 2012-2016). In the Fram Strait, most blue whale 20 Hz call detections occurred August through October, though recently (2015-2018) an increase in blue whale calls was detected in July. At this site, fin whale 20 Hz calls were detected from September through March, documenting their acoustic presence throughout the winter months. At Atwain, both species were recorded in September and October, with fin whales extending into November. Intra- and inter-annual variation in vocal presence of both species, at both locations, were detected (partly related to ice cover), providing novel long-term baseline information for the occurrence of these species in a region where traditional survey methods are seasonally limited. Such data will be valuable for investigating how environmental change impacts the phenology of seasonally resident cetaceans in the High Arctic.

Sudden decline of sperm whale sightings may be related to decay of giant squid landings in the Eastern Midriff Island Region in the Gulf of California, Mexico.

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Sperm whales (*Physeter macrocephalus*) are one of the toothed whale populations known in the Gulf of California, a priority site for conservation where the marine mammal diversity overlaps with the abundance of the largest marine fisheries in Mexico. Even though their presence in the Gulf has been known for centuries, there is little information on sperm whale population dynamics in this site. We conducted a study with monitoring data from 2010 to 2018, in which we recorded sperm whale sightings in the Eastern Midriff Island Region of the Gulf of California, and then applied photo-identification techniques to identify individuals. From our surveys, we found that between 2015 and 2018, the individuals' occurrence dropped to zero, leading us to analyse what could be influencing this trend. We found a strong positive correlation (r^2 = 0.8) between each season's sperm whale encounter rate, measured in whales per effort hour, and yearly landings of jumbo squid (*Dosidicus gigas*), a major fishery in the Gulf and the sperm whale's main

prey in the area. Additionally, we applied an open-population Jolly-Seber (POPAN) mark-recapture model to estimate the population size for sperm whales (2010-2015), which resulted in a negative trend. These results seem to confirm that sperm whale occurrence is strongly affected by food availability, even in habitats were site fidelity was once high. The sperm whale's relationship with jumbo squid is complex and might be influenced by oceanographic conditions such as El Niño and La Niña. Detailed studies on this trophic relationship in the region could be useful to better understand sperm whale population dynamics in the Gulf of California.

High frequency vocalizations of Amazon river dolphins (Inia geoffrensis), potential function of acoustic communication in shallow water systems.

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Amazon river dolphin has been known to produce high frequency vocalizations, which are different from echolocation signals. The function of this vocalization has been not well known. Behavioral and acoustic biologging was conducted on 8 botos in Mamirauá Sustainable Development Reserve, Brazil. Three-dimensional body accelerations, swimming depth and sounds from 20 Hz to 24 kHz were recorded during 13 to 147 minutes after release. The high frequency sounds having dominant frequency between 9-13 kHz were recorded in three dolphins. They dove regularly with two minutes periodical dives up to 4-6 m in maximum depth followed by one or two surfacing. Vocalizations were recorded in the middle of each dive, not nearby the surface. Most frequent sound production was observed just before changing the behavioral phase turned to the active swimming with non-periodic respiration and depth profiles. No high frequency vocalization was recorded in the rest of 5 individuals except for clicks. All the 5 dolphins kept active swimming during entire recording periods. Because of the Lloyd's mirror effect, low frequency sound does not travel long distance in shallow water. The sound source and the receiver should be much deeper than the sound wavelength. As the result of the mirror effect, Amazon river dolphins should avoided surface from acoustic communication. Assuming the minimum frequency of vocalization at 9 kHz and 2 m depth of the phonating and receiver dolphins, the range limit of sound traveling is calculated as 301 m, which is the physical constrain of communication distance. To communicate each other in the shallow water systems, the sound producer and the receiver should be deeper in the water column for a prolonged duration. The regular periodic dive pattern could be for effective sound propagation and eavesdropping to communicate among conspecifics. Funded by SATREPS (JST-JICA).

Distribution of common dolphins (Delphinus delphis) off São Miguel Island, Azores: Using "Highly Identifiable Individuals" to determine a potential residency pattern.

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Short-beaked common dolphins (*Delphinus delphis*) are the most sighted species in the Azores archipelago. Yet, little is known about their spatial and temporal distribution, seasonal variation and residency patterns in this region. In order to better understand the common dolphins sighted off São Miguel Island, Azores, a 10-year sightings dataset (2009-2018), collected by opportunistic observations on board whale-watching vessels, has been used to analyse the temporal and spatial distribution, and seasonal variation.

As common dolphins occur in large numbers in the study area, and photo-identification can be extremely time consuming in terms of data collection and processing, no public catalogue has been created for the Azores archipelago yet. However, several studies in New Zealand, Australia and Greece have shown that photo-identification of common dolphins, using pigmentation and markings on dorsal fins, is reliable. In this study, a selection of "highly identifiable individuals" (HIIs) has been used to build a catalogue and determine the re-sighting rate of marked common dolphins. HIIs have been defined as dolphins with highly distinctive nicks/notches and/or extensive pigmentation of the left side of the dorsal fin. The research focus on HIIs aims to facilitate the data collection from a platform of opportunity, such as whale-watching vessels, as the time spent with the species is limited.

Pictures have been collected between 2018 and 2019.The initial results show the presence of common dolphins year-round, with larger groups in summer months. Several HIIs have been re-sighted in the months of July and August 2018. These findings may indicate the presence of certain individuals within the same season around São Miguel. Further comparisons between seasons and the two years of the study will allow to determine if some individuals are resident off the coast of São Miguel Island.

Modelling the bioaccumulation of microplastics in a marine mammalian food web of the Northeastern Pacific

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Microplastics (MPs) are emerging pollutants of concern in the oceans and given their small size (<5mm), they can be directly or indirectly ingested by zooplankton, fish, and marine mammals. Bioaccumulation of MPs is scarcely known in marine mammalian foodwebs. To understand whether MPs bioaccumulate in cetaceans, a bioaccumulation model for microplastics was developed for the southern resident killer whale (SRKW) foodweb of the Northeastern Pacific with documented dietary uptake rates. MP concentrations of 0.66 and 3.20 particles/L in seawater and of 66 and 100 particles/kg in sediment observed around SRKW critical habitats, were used as abiotic concentrations to project simulation of high and low MP concentration scenarios. Elimination rates were calculated from documented retention time of MPs observed in some invertebrates and planktivorous fish. The response of the organisms to the abiotic exposure was projected by a plausible species-specific bioaccumulation potential of MPs. Both SRKW and its main prey (Chinook salmon) accumulated MPs from the diet, but the level of bioaccumulation in SRKW was relatively lower compared to that projected in prey in the short- or long-terms, as indicated by the biomagnification factor (BMF = predator[SRKW]/prey[Chinook salmon], where BMF<1 =no biomagnification; BMF>1 =biomagnification), ranging 0.30−0.90, except at 10 or 50 days of simulation when the BMF values ranged 1.0−1.1 and 1.2−1.5, under each scenario, respectively. The model projected that SRKW can retain 0.30−1.0 MP at 35 and 45 days to 2.5−4.0 MPs at 55 days, but with total elimination of MPs projected at 60 or 70 days. Moderate to high MP accumulation (i.e. >27 to 700 MPs) at 65 and 75 days was also projected in SRKW due to re-exposure to contaminated prey. This model can be applied as a practical tool to assess MP bioaccumulation in marine mammal species.

Habitat use of minke whales in Skjálfandi Bay, North Iceland.

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The focus of this study are distribution and habitat use of minke whales (*Balaenoptera acutorostrata*) from 2005 - 2018 in Skjálfandi Bay, North Iceland. The data was set up through a continuous sighting surveys by trained volunteer using whale watching vessels as research platform. Interannual and seasonal distribution changes were investigated. Seasonal changes seem to be according to prey distributions: fish distribution obtained from fishermen interviews and Chlorophyll-a densities from satellite images. Annual changes might originate from dynamics in the whale community and a humpback whale (*Megaptera novaeangliae*) abundance increase through the years. Investigating dynamics of the minke population itself the sightings per unit effort were calculated. Less SPUE seemed to occur during the years 2006 - 2009, followed by a strong increase to similar values than found in 2005. Variations and a slowly declining trend were found for the years after 2010. A GLM will be performed to assess significant changes in SPUE between years and months. Significant declines will be discussed on conservational context regarding Iceland's commercial whaling activities. Additionally, we aim to test for small scale site fidelity and spatial group clustering using the R-package wildlifeDI. Therefore, the sighting data is currently being joined with a Photo-ID catalogue. As outcome of this research we expect site fidelity to occur for single individuals over years and to find spatial group clustering in adjacent ranges as found previously in other areas for minke whales. Results as not an infinite number of individuals sharing space equally, but groups occupying adjacent ranges would lead to important implications for conservation of the species and management of protected areas without whaling.

A whale bio-echosounder tell-tale of niche diversification in deep-diving beaked and pilot whales

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Deep-diving whales must meet their energetic requirements by foraging efficiently in time-limited dives. Pilot whales are active hunters that sprint to catch few prey items while beaked whales target more low-caloric prey. Within depth-stratified pelagic habitats, the mesopelagic deep scattering layer constitutes the highest biomass concentration in the oceans, followed by the Benthic Boundary Layer (BBL). In order to investigate if there is a niche diversification between similar-sized deep-diving odontoceti with different hunting tactics via segregation within the water-column, we analyzed acoustic and movement data recorded by suction-cup attached DTAGs deployed on 28 short-finned pilot whales (121 dives) and 14 Blainville´s beaked whales (60) in the Canary Islands, and 10 Cuvier´s beaked whales (34) in the Ligurian Sea (Italy). Using echolocation clicks as bio-echosounders, we measured the time delay between the tagged whale clicks and their echoes reflected by the seafloor to calculate the altitude of the whales when attempting to capture prey (i.e: emitting buzzes). We show that pilot whales prey almost equally between the epipelagic and mesopelagic (46 and 53%), with few buzzes within the BBL (1%). Cuvier´s and Blainville´s beaked whales bypass epipelagic prey and forage within the mesopelagic (67 and 80%) and bathypelagic (29 and 5%). The BBL is exploited by Cuvier's (4% of the buzzes), which even physically probe the seafloor, and by Blainville's while following the seafloor slope (15%). Pilot whales presented diel patterns, foraging more in the epipelagic than in the mesopelagic during the night. Cuvier's beaked whales increased their bathypelagic buzzes (from 11 to 47%) at night, while Blainville's become slightly more mesopelagic. Our data supports previous findings regarding these species foraging strategies: pilot whales would target at night the more active migrant organisms of the DSL while beaked whales forage on low-caloric non-migrant meso-, bathy- and benthopelagic organisms, presenting a niche diversification.

Predictive habitat models of bottlenose dolphins (Tursiops truncatus) in the Sicilian Channel (Mediterranean Sea).

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Bottlenose dolphin (*Tursiops truncatus*) is a species listed in Annex II of the Habitat Directive which require to select, designate and protect sites that support these species in order to create a network of marine protected areas. To meet these requirements, knowledge on distribution and habitat preferences of species is fundamental. Predictive habitat models can provide critical information that is necessary for species conservation. In this study, using Maximum Entropy modelling (MAXENT), we generated spatial predictions of bottlenose dolphins in the waters along Agrigento's coast in the Sicilian Channel (Mediterranean Sea). According to previous studies conducted in the area, bottlenose dolphins were frequently encountered with a rate of 72% and often interact with professional fisheries, 56% of the sightings. In this work was analyzed data collected during summer seasons from 2016 to 2018, 60 pods of bottlenose dolphins were sighted, 48 of this were feeding beyond fisheries boats. To run MAXENT model four predictive variables were considered: average depth, bottom slope, distance from the shoreline, and the number of professional fishing boat. The goodness of the model is demonstrated by AUC greater than 0.9, meaning an outstanding discrimination. The proximity to the coast was the variable that best predicts dolphins distribution, followed by the average depth, slope of the sea bottom and lastly the number of fishing boat. According to the model, this species prefers water from 3 to 7 nautical miles far from the shoreline with depth ranged from 30 to 100 m. Despite the strong interaction with fisheries, it contributes to the model for just 0.2%, even if a reduction in probability presence of bottlenose dolphins results when numbers of fishing boat increase. This study provides an example of a presence-only habitat model used to inform the management of a species for which habitat preferences are poorly understood.

Hologenomics for conservation: A first test of utility using New Zealand's endemic Māui and Hector's dolphins.

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In the face of the current biodiversity crisis, conservation genetics has been quick to adopt the latest genomic approaches to improve detection of demographic bottlenecks, inbreeding, selection leading to local adaptation, and the spread of maladapted genes. A new approach that has not yet been used in conservation genetics is hologenomics, where the genome of a host organism is considered in tandem with the microbes that naturally occur throughout the host's body (the microbiome). The New Zealand endemic Māui dolphin (*Cephalorhynchus hectori maui*), thought to number only ~63 individuals, and Hector's dolphin (*C. h. hectori*), thought to number a total of ~24,000 individuals but subdivided into several regional populations, provide a compelling test case of the utility of hologenomics, as significant uncertainty remains about: (i) the potential for genetic interchange between these two subspecies; (ii) changes in their population sizes through time, (iii) the risks of inbreeding within each subspecies, and (iv) individual susceptibility to pathogens e.g. toxoplasmosis. Using an extensive database of individual Hector's and Māui dolphins collected throughout their ranges, we are sequencing both host and microbial genomes to elucidate the hologenomic basis of disease susceptibility; assess the presence (or absence) of defining hologenomic characteristics between these subspecies; and use the increased resolution of the hologenome to describe more precisely anthropogenic impacts, such as fisheries related mortality, on population sizes and connectivity. This will provide a first 'proof-of-concept' with the potential to revolutionise conservation biology on a global scale, as well as improve management of New Zealand's only endemic cetacean.

Stomach content analysis of stranded small cetaceans from Abu Dhabi and Dubai, United Arab Emirates (UAE).

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The United Arab Emirates (UAE) coastal waters host a number of small cetacean species including the Indian Ocean humpback dolphin (*Sousa plumbea*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*). Little is known about the ecology of these small cetaceans in the Arabian/Persian Gulf (Gulf). Further studies to better understand their current status are paramount to support their conservation needs, especially considering their coastal habits and the semi-enclosed feature of the Gulf. Dietary investigations provide valuable information on cetacean feeding behavior and predator-prey relationships. This study reports on the stomach contents of one Indian Ocean humpback dolphin and three Indo-Pacific bottlenose dolphins found stranded along the shores of Dubai and Abu Dhabi. Stomach Content Analysis was used to identify prey items in cetacean stomachs. Otolith analysis was used to identify fish, and fish bones were used for secondary confirmation. Cephalopods were identified through beak analysis. A total of 137 fish, representing 11 families and 14 genera, were counted in the four stomachs. Four families of fish were found in more than one stomach: jacks (Carangidae), snappers (Lutjanidae), seabream (Sparidae) and goatfish (Mullidae). The family with the highest number of fish was mojarras (Gerreidae), however were all found in one of the three *Tursiops* stomachs, followed by Carangidae and Sparidae. A total of six cephalopod beaks were found in one stomach and classified as squid (Teuthoidae). Comparison with published data from Oman revealed five overlapping fish genera for the same two dolphin species. Additionally, 80% of the identified prey items belonged to species regularly sold in fish markets throughout the UAE. This shows a significant overlap between cetacean diet and local commercial fishery species deemed as being over exploited.

Modelling the habitat preferences of sperm whales off the north-west coast of Scotland

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The distribution and habitat preferences of male sperm whales (*Physeter macrocephalus*) off the north-west coast of Scotland are poorly understood. Understanding the factors which drive distribution is critical in understanding the species ecology and has important conservation implications. The habitat preferences of sperm whales were modelled in relation to environmental variables to determine distribution and habitat preferences and define critical areas for sperm whales in the waters off the north-west coast of Scotland. This study used acoustic data collected on Extended Ellet Line (EEL) hydrographic survey in June 2016. Sperm whales make loud, near-continuous echolocation clicks, making passive acoustics the most reliable method of detecting animals. A Generalised Additive Model (GAM) was used to model sperm whale acoustic occurrence with Generalised Estimating Equations (GEEs) to account for temporal autocorrelation, resulting from the large distances over which sperm whales could be heard. A range of bathymetric and oceanographic variables including: depth, slope, sea surface temperature (SST) and the distance to, strength and persistence of thermal fronts, were available for inclusion in the model. Results suggest that sperm whales off the north-west coast of Scotland are most likely to be encountered in depths between 1500-2500m and temperatures between 10-14°C. Highest aggregations were also associated with areas of high internal wave activity around Anton Dorhn seamount and north of Rockall Bank as determined by numerical models that are likely to aggregate their squid prey. These areas were also associated with deep scattering layers around 500m depth identified from concurrent fisheries echosounder data. These results suggest that the deep waters off NW Scotland provide an important foraging habitat for sperm whales, with implications for conservation.

Locomotive response of narwhal (Monodon monoceros) to large vessel traffic in Milne Inlet, Nunavut.

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Narwhal (*Monodon monoceros*) in the Eastern Canadian Arctic may be subject to a changing environment as a result of increased commercial shipping activity. To assess the potential effects of commercial shipping on narwhal, behavioral response to large vessels (≥ 100 m) transiting along an active shipping route in Milne Inlet, Nunavut was investigated by comparing animal-borne tag data with ship-tracking data collected during the 2017 open-water season. High resolution horizontal and vertical (dive) movement data were obtained for four narwhal outfitted with a combination of Argos satellite biologging tags (SPLASH-10 backpack tag and MiniPAT tow tag; Wildlife Computers) over a period of 27 to 38 days. Concurrently, vessel traffic data were obtained using a combination of shore-based and satellite-based Automated Identification System (AIS) data. A total of 67 encounters were identified in which the closest point of approach (CPA) between individual narwhal and a given vessel was within 3km and no narwhal travelled within 0.1 km of a vessel over the course of the study (mean 1.3 km; SD = 0.8 km). For each vessel-whale encounter, behavioral responses analyzed included changes in narwhal surface movement (e.g. horizontal avoidance) and changes in subsurface movement (i.e. dive behavior); with the latter component including potential changes in dive rate, dive duration, bottom time, descent velocity, and proportional time spent at surface during encounters with large vessels. Although measurable changes in surface behavior (e.g. increased turning rate in the presence of vessels) and certain dive behaviors (e.g. increased likelihood of deep dives in the presence of vessels) were observed, the response of narwhal to vessel encounters with vessels varied among individuals and among encounters by the same individual.

OK Google: Where are the humpback whales? Identification of trends in Hawaiian Island humpback whale occurrence using machine learning on passive acoustic data.

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High inter-call variability in humpback whale song provides a unique challenge to the development of accurate and precise automated detection and classification algorithms for use in passive acoustic monitoring data. While relatively simple spectral or

temporal detectors work well for other baleen whales, humpback whale calls require a more adaptive approach. The Pacific Islands Fisheries Science Center (PIFSC) partnered with Google AI to develop a machine learning (ML) model capable of recognizing humpback song with high precision and recall despite the large variability between calls, through time, and across vast geographic regions. PIFSC maintains a network of seafloor-mounted long-term autonomous recording sites to listen for sounds produced by cetaceans, including humpback whales. Of particular interest are the trends in the distribution and movements of humpback whales throughout the Pacific, and particularly within the Hawaiian Archipelago, as sighting rates in the main Hawaiian Islands have declined in recent years. The acoustic network is well-suited to investigating these types of changing trends with 13 monitoring sites extending from Hawaii to the Mariana Archipelago and data reaching back more than a decade at several sites. The Google ML model was used to successfully annotate humpback whale calls within 75 second chunks of acoustic data for the entire data archive, which totals more than 170,000 hours of recordings. We used the annotated data to identify patterns of humpback whale occurrence within the Hawaiian Islands over the past decade. The ML model combined with our long term acoustic dataset provides a comprehensive and consistent metric of the occurrence of singing humpback whales between sites and over long-time periods. The success of our collaboration with Google AI demonstrates the powerful possibilities achievable when science agencies and industry partner together to address conservation questions using large data sets and cutting-edge industry tools.

Development of a fine-scale activity proxy to estimate the energetic cost of swimming in common bottlenose dolphins

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The rapid advancement of bio-logging tools has led to significant interest in developing tag-based activity proxies of energy expenditure for marine mammals. The use of activity as a proxy for energetics has demonstrated mixed results; in some cases, diving, gliding, and details of tag attachment can confound the relationship between activity and energy expenditure. It is becoming clear that we need species-specific calibrations to understand the feasibility and limitations of these proxies. Therefore, to develop and calibrate an activity-energetics proxy in common bottlenose dolphins, *Tursiops truncatus*, we conducted 37 swim trials with five male dolphins at Dolphin Quest Oahu. In each trial, dolphins swam 8-12 60-meter laps while wearing suction-cup attached tri-axial accelerometry tags. We measured all breaths using novel breath-by-breath respirometry between laps which permitted fine scale resolution of respiratory flow, expired O_2 and CO_2 composition, and O_2 consumption ($\dot{V}O_2$) and CO_2 production ($\dot{V}CO_2$) rates. We calculated Overall Dynamic Body Acceleration (ODBA) for every dolphin in each trial. Inter-trial swim speeds varied, and after steady-state $\dot{V}O_2$ was reached at lap 5, activity (ODBA) and energy expenditure ($\dot{V}O_2$) were assessed as average rates of the remaining laps. The metabolic cost of locomotion was estimated by subtracting the resting $\dot{V}O_2$ measurements from the steady state $\dot{V}O_2$. Generalized Linear Models, with individual as a random effect, showed a significant relationship ($p<0.01$, $R^2=0.6$) between ODBA and $\dot{V}O_2$. The highest $\dot{V}O_2$ rates were below values associated with the onset of lactate production in other studies, indicating that these trials were primarily aerobic. This calibrated proxy substantially improves current methods for estimating locomotion costs and provides an opportunity to quantify the energetic effects of natural and anthropogenic disturbance in wild dolphins.

Skeletal injuries provide insight into the cryptic lives of beaked whales

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Beaked whales exhibit extreme morphology, including aspects of their bone structure and design. Osteological structure and composition within a single animal can range from highly porous osseous tissue, as in post-cranial skeletal elements, to extremely dense hypermineralized components, such as the rostra of certain species. As a living tissue, bone not only serves a structural role, but also contributes to the overall physiological function of various systems and the organism as a whole. When an injury occurs to

bone tissue, its function may be compromised, resulting in negative impacts to the health of the animal. We examined cranial and post-cranial bones of five North Atlantic beaked whale species (*Mesoplodon bidens, M. densirostris, M. mirus, M. europaeus*, and *Ziphius cavirostris*) available in institutional research collections and documented signs of antemortem bone injury. We summarized anatomical locations of osteological trauma for only those cases showing evidence of healing prior to death in order to exclude observations of damage to the bones that may have occurred postmortem; this likely resulted in underestimates of injuries that occurred perimortem. Mandibular fractures were observed more often in males than females for all species examined. Given the heavy conspecific tooth-rake scarring often observed externally on males, this finding fits with our hypothesis that males would exhibit increased incidence of associated mandibular trauma. However, post-cranial fractures were observed near-equally in both sexes for all species examined. Post-cranial fractures were observed primarily in spinous processes of the thoracic, lumbar, and caudal vertebrae and ribs, with some fractures also observed in vertebral transverse processes, rostra, and cervical vertebrae. Observations on the prevalence, anatomical location, and severity of injury between sexes, age classes, and among species are providing valuable insights into beaked whale life history, behavior, bone physiology, and physiological response to antemortem injury.

Experimental evaluation of two computer-assisted dorsal fin identification systems

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Photographic-identification of bottlenose dolphins using features on the dorsal fin is a well-established and useful tool for tracking individuals over time; however, this method can be labor-intensive especially when dealing with large catalogs and/or infrequently surveyed populations. Algorithms have been developed that can find a fin in an image, characterize the features of the trailing edge of the fin, and compare the fin to a catalog of known individuals to generate a ranking based on dorsal fin similarity. We tested the performance of two platforms that have integrated fin-matching algorithms for bottlenose dolphin photo-ID: finFindR and FlukeBook TM. A test data set comprised of 604 images of 194 unique individuals was compared to a catalog of 26,706 images of 888 known individuals within each platform. Images tested included all quality levels (excellent – Q1, average – Q2, poor – Q3) of all fin distinctiveness levels (very distinct – D1, average level of distinctiveness – D2, low distinctiveness – D3, non-distinct – D4). Both algorithms performed well with 96.92 % and 95.90 % of Q1, Q2 and D1, D2 fins matched, respectively. Each platform made matches that the other platform missed. When matches between platforms were combined, 98.97 % of Q1, Q2 and D1, D2 images were matched and 95.55% of all images (regardless of image quality or fin distinctiveness) were matched. Efforts are underway to incorporate the algorithms used by both platforms into a single system to improve overall match performance and streamline the user interface so that it can be easily incorporated into the photo-ID workflow. These platforms provide reliable and accurate computer vision ranking of potential matches to marked individuals based on dorsal fin photographs within a few minutes, greatly reducing the time required to search manually for potential matches.

Syntactic features in humpback whale song revealed through network analysis facilitate population-wide cultural learning.

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The arrangement of acoustic signals into vocal displays is typically governed by a set of syntactic rules. However, there is a limited understanding of which syntactic rules might be shared by the complex arrangements of vocal displays in different taxa. Recent work, focused on the complex repertoires and syntax of songbirds, has taken a new approach to investigating syntax. Network-based modelling quantifies song features such as the connectivity between signals (adjacent signals in a sequence) and other patterns in their arrangements. These features indicate structural complexity and are often the basis of syntax. Here, we apply similar network-based modelling to a mammalian display, the complex, hierarchically structured songs of eastern Australian humpback whales (*Megaptera novaeangliae*) over 13 consecutive years. Given the song's evolving pattern each year and the cultural conformity of

males in a population to learning that pattern, network modelling was applied to capture the patterns of multiple song types. In every year, song arrangements displayed 'small-world' network structure characterised by clusters of highly connected sounds (units). The transitions between these connected units were further characterised by a combination of patterns indicative of structural stability and patterns indicative of structural variability. The presence of these structural song features may facilitate vocal learning. Similar small-world structures and transition patterns are also found in the song displays of several oscine species, indicating that syntactic patterns may be common among cultural learning across multiple taxa. Understanding the syntactic rules governing the arrangement and structure of vocalisations in multiple, independently evolving lineages will indicate what rules may be important to the evolution of vocal culture.

Mechanisms of tolerance to hypoxia and oxidative stress in primary endothelial cells isolated from seals.

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Marine mammals experience hypoxemia and peripheral ischemia secondary to the cardiovascular adjustments supporting diving. In terrestrial mammals, endothelial activation during ischemia stimulates inflammatory pathways, promotes oxidant generation, and impairs vasoregulation, ultimately leading to cell death and tissue injury. Protection against such injury is paramount in diving mammals, but the molecular mechanisms underlying this protection remain unknown. We developed a live, proliferative cell culture system using primary endothelial cells isolated from seal placental arteries to study the endothelial response to simulated diving *ex vivo*. Seal endothelial cell monolayers demonstrate the cobblestone-like morphology characteristic of endothelial cells. Similarly, seal endothelial cells stain positive for the endothelial markers platelet endothelial adhesion molecular (CD31) and vascular endothelial cadherin (CD144) by immunofluorescence and flow cytometry. Seal endothelial cells in primary culture are capable of incorporating dil-acetylated low-density lipoprotein, and generate oxidants after stimulation with angiotensin II and phorbol ester, suggesting that this system is biologically functional. In seal endothelial cells exposed to 1% oxygen, hypoxia-inducible factor 1α (HIF-1α) protein expression increases 20-fold from normoxic levels within 15 minutes, while equivalent human cells demonstrate a 7.5-fold increase. Seal cells maintain a 150-fold increase in HIF-1α protein expression across 2, 4, and 6 hours of hypoxia while expression in human cells peaks (80-fold increase) between 2 and 4 hours and declines to 30-fold higher than baseline by 6 hours. Acute hypoxia/reoxygenation exposure fails to alter oxidant generation in seal endothelial cells, while oxidant generation is increased 35% in human cells ($\alpha = 0.05$; $p=0.25$ and 0.04, respectively). Our data show that seal endothelial cells in primary culture are a viable, novel model to study differential regulation of hypoxia tolerance. Furthermore, our results suggest that seal endothelial cells mount a more rapid, sustained, and controlled response to hypoxia than human cells.

The biology of a mesoparasitic copepod on whales: Pennella balaenopterae (Copepoda; Pennellidae).

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Pennella balaenopterae is a mesoparasitic copepod found on marine mammals. This crustacean is among the largest of the parasitic copepods. Information on *P. balaenopterae* is sparse; little is known of the life cycle of this species and there is no information of a presumed intermediate host(s). A literature review compares the marine mammal hosts and their localities; however presence appears to be highly underreported as well as misreported (due to multiple misspellings of the scientific name). Access to complete and intact specimens is challenging due to the pelagic nature of the marine mammal hosts. Coordination with marine mammal stranding networks has provided new host records, as well as specimens for examination. Additionally, Eastern North Pacific Mark-Recapture (photo identification) studies of fin whales from 2003 to 2013 have documented presence of *P. balaenopterae* on 64% of individual whales recorded. Comparing early (December through May) versus late (June through November) annual parasite scores suggest the same whale is much more likely to have greater numbers of visible parasites later in the year, potentially indicating seasonality. This use of photo identification studies

on whales provides novel insights on growth and development rates of *P. balaenopterae*

Machine learning techniques to automate Steller sea lion ID data extraction from high-resolution images.

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The collection of digital imagery via remote cameras has become a common tool in wildlife research, especially for populations in remote, inhospitable sites, such as volcanic islands inhabited by Steller sea lions (SSL) in the North Pacific. SSL declined dramatically throughout much of Alaska and the Russian Far East, likely by over 75%, from the mid-1970's through the late 1990's. The populations in the Western Aleutian Islands and nearby Commander Islands (Russia) continue to decline for unknown reasons. It is important to collect demographic data at these sites to determine spatial patterns in age-specific survival and reproduction across the range. However, access is limited and expensive. In 2012, we began deploying customized autonomous cameras to collect data on SSL sites. However, the extraction of identifiable information from the large quantity of images is a logistical and time-consuming burden. To date, we have collected over 10 million images from most of the SSL rookeries in Russia but have only been able to review approximately 20%. To remedy this problem, we developed machine learning algorithms using R, KERAS, and TensorFlow to automate and accelerate marked SSL ID extraction. A U-Net convolutional neural network was used to detect branded SSLs among unmarked SSL on the image, while the VGG16 neural network was used to classify branded animals. In our pilot study the data extraction from 30,269 images took about 96 hours of machine time, while an observer needed 960 hours to manually review the same number of images. The Deep learning algorithms rarely missed animals (missing 5% of animal encounters seen by an observer) but they discovered more IDs than observers (40% more ID identifications). Using this automated approach, we significantly reduced the time needed to extract ID information, improved performance and unified analysis across all sites.

Drivers of the spatial distribution of great whales in the Southern Pacific Ocean

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Within the southern Pacific Ocean, the great whales form a diverse and significant group of marine mammals. They are also highly relevant for conservation due to their high level of threat from human activities and global climate change. In the South Pacific Ocean, the spatial distribution patterns of these species are not well understood. In order to design appropriate cetacean conservation measures, we need to compile information that allows the understanding of their distribution patterns, as well as the interactions with negative impacts.

This study aims to assess the distribution patterns of four great whale species; the blue whale; humpback whale; southern right whale and sperm whale. A large database which contained sighting data that spanned several decades was used, and additionally, three environmental variables were included in the models: bathymetry, distance to the coast and sea surface temperature (SST). Species distribution models' (SDM) tools were applied to identify the most important distribution drivers. Furthermore, these variables were also included in models to estimate the overlap of niche levels between species.

Our results show that the most important drivers of spatial distribution for all four species include SST and bathymetry. Sperm whales show very low levels of niche overlap with the other species. the other three whale species have low to medium levels of niche overlap, which is reflected in the projected distribution.

These results indicate, that the great whales' spatial distribution show significant differences between species. The baleen whales analyzed here consume similar prey items within the southern Pacific Ocean, their differences in distribution patterns are important for avoiding resource competition. In addition, the high importance of SST as a spatial distribution pattern for the blue whale highlights the risk of this species under climate warming scenarios.

Aggregation vs segregation: Temporal dynamics and interspecific co-occurrence in an insular ecosystem with high cetacean diversity.

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Understanding ecosystem function is essential for proper ecosystem-based management, yet, such knowledge is still unbalanced for the oceanic environment. Here, we aim to analyze how cetacean species co-occur throughout time in a small (800km^2) pelagic habitat (Madeira Island, NE Atlantic). A large dataset of effort-related sighting data collected on a daily basis from whale-watching boats between 2005-2018 (mean of 322 surveyed days per year, SD=15) was used to model the species' inter- and intra-annual (monthly) distribution patterns. An exploratory data analysis from 9905 daily sightings comprising 24 species showed i) no significant variations in group size for any species, ii) no inter-annual trend for any species, and iii) heterogenous intra-annual occurrence patterns for 15 species. These included year-round occurrence (with no significant intra-annual variation) for four species (Ttr, Pma, Mde, Ggr), and marked seasonal fluctuation (with significant intra-annual variation) for a wide spectrum of taxonomic groups covering small delphinids (Sfr, Sco, Dde, Sbr), large delphinids (Gma), Kogiidae and (five species of) baleen whales. Additionally, while some of the species with marked seasonal fluctuation showed temporal synchrony (e.g. Bbr-Sfr-Sbr with a seasonal peak in summer, or the migratory baleen whales in spring), others showed temporal segregation (e.g. Dde with peak in May and Gma in October). An overall picture shows that the temporal distribution of each species works like a piece of a 'year-round puzzle'. This study highlights the importance of long term data series to properly infer on the interspecific temporal co-occurrence within an area, and serves as an example of science (by using platforms of opportunity) towards conservation. Finally, a discussion on the best modelling approach (e.g. ARIMA, GAMMs, wavelet coherence) to address common biases in time series data, such as autocorrelation, is also presented.

Comparison of dolphin presence at two locations in the Istanbul Strait, Turkey, by the passive acoustic monitoring system

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The Istanbul Strait (Bosphorus) is a part of the only connection between the Black Sea and Mediterranean, thus recognized as a critical habitat for cetaceans. Previous studies confirmed the occurrence of cetaceans especially in spring-summer months and indicated the areas of higher sighting frequency, mainly based on visual observation. To understand their occurrence and habitat use at a finer scale, this study compares the passive acoustic monitoring data collected by an acoustic event recorder, A-tag, at two locations in the Strait, namely Poyrazköy (near the Black Sea) and Baltalimani (middle of the strait) in April-July 2013-2016. Based on the intensity ratios of two-band frequencies (130 and 70 kHz), only data classified as delphinids (bottlenose dolphins and common dolphins) were analyzed. In total, 260,379 click trains (CTs) were detected in Poyrazköy, 13,733 CTs in Baltalimani, showing that Poyrazköy showed twenty-fold more detections throughout the study period (264 days). Diel pattern was different between two locations. Continuous presense with slight decrease in early morning and late evening was observed in Poyrazköy, while a typical shift to night time was detected in Baltalimani. Short Inter Click Intervals (ICIs) implying feeding were observed in both areas in early spring, followed by gradual shift to travelling implied by longer ICIs. Dolphins use both areas for feeding during the high fish migration season, but more intensely in Poyrazköy. Besides, in Poyrazköy, higher ICIs (>140ms) implying resting were also observed during late spring-summer. Although these two areas are close (about 15 km apart), dolphins seem to use them differently due to factors such as marine traffic, fish availability, human disturbance. When elaborating the conservation measures for these vulnerable animals, such local difference on a fine scale should also be taken into consideration.

Genomic evidence for hybrid speciation in Stenella dolphins

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Hybrid speciation is a process by which a species originates as a mixture between two parental species. Although such cases of hybrid speciation have been described in plants, fish and insects, they are considered exceptionally rare in mammals. Evidence has been presented before for a marine mammal, *Stenella clymene*, arising through natural hybridization between two other species, the spinner dolphin, *S. longirostris* and the striped dolphin, *S. coeruleoalba.* Evidence for this hypothesis came from incongruent mitochondrial and nuclear DNA phylogenies and intermediate morphological characters found in *S. clymene*. In this study we build on previous analysis by generating significant new data in the form of genome-wide single nucleotide polymorphisms obtained from the three species to further elucidate the putative hybrid origin of *S. clymene*. A total of 31,562 single nucleotide polymorphisms (SNPs) were obtained using a genotyping-by-sequencing (GBS) protocol for a total of 54 samples (21 *S. longirostris* from the Pacific and Indian Oceans, 14 *S. clymene* from the Atlantic Ocean and 19 *S. coeruleoalba* from the Pacific, Atlantic and Indian Oceans). Phylogenetic, principal component and admixture analyses showed that *S. clymene* is genetically distinct form its putative parental species, with approximately 70% of its ancestry derived from *S. longisrostris* and 30% from *S. coeruleoalba.* Demographic modelling based on the site-frequency spectrum supports that the best-fitting model of origin for *S. clymene* is the model where it is considered a hybrid lineage between *S. longirostris* and *S. coerueloalba*. Evidence of introgression is further supported by the D-statistic, used to detect gene flow between closely related species. Our study emphasizes the power of population genomic analysis for understanding complex evolutionary histories and highlights the importance of elucidating speciation processes in the face of gene flow in non-model mammal species.

A study of beluga (Delphinapterus leucas) vocal ontogeny.

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There is a shortage of literature regarding beluga (*Delphinapterus leucas*) vocal

ontogeny, as presently, there has only been one published study on the vocal

development of beluga calves, despite the value of ontogenetic studies for our

understanding of sound-centered species. Here, we offer the second longitudinal study of

beluga vocal development. Using a calibrated digital hydrophone with a sampling rate of

256 kHz, we investigated the vocal progression of a male beluga calf over his first two years of life. From his first day, the calf produced broadband pulse trains with upper frequency limits extending past the study's Nyquist frequency (128 kHz); higher than what was initially reported in prior studies limited by lower sampling rates. Pulse signals were the most common sound type in the calf's vocal repertoire during his first year. Mixed calls were produced in month

one but were rare overall and not regularly produced until the calf's fifth month of life.

Tonal production was also infrequent and not apparent until month four. Over the calf's

first month of life, pulse repetition rate, source level, and third quartile frequencies of the

calf's pulse trains increased significantly. First and third quartile, center, and peak

frequencies increased significantly over the first year, as did pulse repetition rate and call

duration. In his second year of life, the calf developed a contact call that was most similar

to his mother's, analogous to the contact call acquisition of other beluga calves. Parallel

findings from this and previous studies imply species-specific trends in vocal

development.

Using drone images as a new tool for fin whale (Balaenoptera physalus) photo-identification
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Unmanned Aerial Vehicles (UAVs, drones) are a novel, economical and non-invasive tool for cetacean observation and monitoring. During the Fin whale Project, conducted along the Garraf coast (NE Iberian Peninsula), drones have been used since 2015 in order to obtain behavioural data, monitor body condition as well as to identify fin whale (*Balaenoptera physalus*) individuals. Since 2014, 266 fin whale sightings have been recorded off the Garraf coast and 145 individuals have been identified through traditional photo-identification. For each fin whale sighting, when weather conditions were favourable, a DJI drone was launched from the research vessel. The drone was usually flown between 5m to 30m altitude and whales showed no behavioural response towards the UAV. High-resolution vertical images of the whale's chevron have been analysed and a total of 84 different patterns (individuals) have been catalogued. 60 of these patterns were associated to their dorsal fin photo (taken from the boat). While from a research vessel it is just possible to get the photography of the right or left chevron pigmentation pattern, from the drone point of view it is possible to observe the whole chevron pattern, especially the chevron's central pattern (CCP) where left and right chevron's lines join. Every fin whale recorded with the UAV had a unique CCP that together with the blaze shape turned out to be a unique pattern not possible to observe from a vessel. Animals with weak chevron pigmentation or not distinctive dorsal fin that were not consistently available to match by photos taken from the boat, were successfully identified after analysing their CCP. This new fin whale photo-id methodology has a high potential as a tool for individual and population monitoring, behavioural studies from UAVs videos (tracking each individual while studying its diving pattern, movements and interactions within groups) and morphometric analysis.

Feral cat fiasco: Prioritizing and mitigating the threat of toxoplasmosis to endangered Hawaiian monk seals.
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Prioritizing threats and management strategies for addressing them is a critical component of endangered species management and recovery. It is particularly important given the limited resources most agencies and conservation organizations are working with. When considering threats and strategies, managers must take into account cost, benefit, and feasibility of actions; the relative impact of the threat on the population; roadblocks to implementing solutions; legislative and political tools and obstacles; and public sentiment toward the species and/or management action in question. In this talk, we examine this process through the lens of toxoplasmosis and its impacts on the most endangered pinniped in the United States, the Hawaiian monk seal. Since 2001, there have been a minimum of 11 Hawaiian monk seal deaths from toxoplasmosis. Hawaii lacks native felids, so domestic cats are the only definitive hosts of the parasite *Toxoplasma gondii*, and spread millions of long-lived oocysts into the environment where they infect monk seals and other wildlife. The threat to monk seals is magnified by the disproportionate impact of the disease on female seals and a dearth of preventative or curative measures. NOAA's evaluation and response to the threat of toxoplasmosis is challenged by the highly controversial nature of actions taken to manage cats and the fact that as an agency NOAA has no jurisdiction over cats or the terrestrial spaces they inhabit. Effective management approaches require strategic communications, collaboration across government agencies, and strong social science to support public engagement.

The first successful satellite tag deployment on wild-captured harbor seals in Virginia, USA
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In the last few decades, harbor seals (*Phoca vitulina vitulina*) have expanded their range southward along the U.S. East Coast, but their at-sea movements, dive behavior, and habitat use in this newly expanded range are unknown. To help characterize the degree of potential overlap between seals and sources of anthropogenic disturbance, in particular U.S. Navy military readiness activities, we tagged seven harbor seals (5 females, 2 males) in February 2018 in Virginia (U.S. mid-Atlantic coast), marking the first time wild harbor seals were successfully captured and tagged in the area. We deployed six SPOT, one SPLASH, and five VEMCO acoustic pinger tags, and collected biological samples for future analyses of health, diet, and genetic structure. Tag data included: time spent hauled out vs. in-water, ambient water temperatures, short- (n=7) and long-distance movement patterns (n=6); and dive profiles (one). Tracking data revealed a high degree of site fidelity to the capture location, although while in Virginia waters, individual seals showed strong preference for either inshore (i.e. within the Chesapeake Bay) or offshore areas in the Atlantic. A cumulative habitat-use analysis indicated that 33% (6,062 km^2) of areas of highest habitat utilization for all seven tagged seals overlapped with the Navy's VACAPES operation area. Most seals began leaving Virginia waters in late March, and all, with the exception of one seal whose tag stopped transmitting in late April, had moved north by mid-April 2018. Individual seals exhibited varied haul-out behavior patterns throughout the respective satellite tag deployment periods and across their range from Virginia to Maine (U.S. Northeast coast). Understanding the distribution and abundance, habitat use, and health status of these seal populations will eventually provide the foundation for a range-wide ecosystem-based analysis.

Abiotic stressors expose Peruvian fur seal parental care

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Vulnerable Peruvian fur seals (PFS) *Arctocephalus australis* are genetically isolated subspecies of South American fur seals and have a major breeding colony in Punta San Juan, Peru. PFS display strong site fidelity on densely populated rookeries, likely due to their highly productive foraging environment associated with upwelling. PFS are susceptible to strong environmental fluctuations known as El Niño-Southern Oscillation (ENSO) events, evidenced by sea surface temperature anomaly (SSTA) fluctuations in the Niño 1+2 index. Fur from 2009 (15 adults, 28 pups), 2010 (28 adults, 27 pups) and whiskers from 2015 (6 dam-pup pairs) are comprised of keratin and are isotopically comparable. Stable carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) were employed to detect patterns in foraging habits and how they are reflected in pup tissues. The difference in $\delta^{15}N$ between adult females and pups was no more than 0.8‰ in all three years, and both age classes had an average overall decline of 1.6‰ from 2009 to 2015. This is in contrast with $\delta^{13}C$; females in 2009 and 2015, as well as pups, had nearly identical values. The 2010 adult $\delta^{13}C$ were significantly more enriched by 0.8‰ compared to the other two years, likely indicative of a more productive food web. The adult fur represents growth during the peak of the 2010 moderate La Niña phase (a cooler, productive period), while the pup lanugo, depleted by ~0.5‰ compared to the two other years, was grown during both the ENSO normal and moderate La Niña phase. The lipid-rich diets consumed by the dams of these pups may have provided additional lipid during critical fetal growth that would be represented in depleted $\delta^{13}C$ exhibited in the pup fur. The combined isotopic data from foraging adults and their developing fetuses provide finer-scale resolution of the effects of ecosystem change than population estimates.

Svalbard ringed seal (Pusa hispida) demography in a time of habitat change

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Ringed seals have evolved in close association with Arctic sea ice and depend on it for most aspects of their life history. Sea ice has declined markedly in the Svalbard Archipelago over the last three decades, but little data is available on the effects of

these changes on ringed seal demography. This study compares harvest data on body size, age structure and reproductive rates from three periods spread over the last four decades (A: 1981-1984 (n=277), B: 2002-2004 (n=272) and C: 2012-2018 (n=213)) to study potential changes in these parameters. Body length showed no clear pattern over the three study periods; males were longer in period C while females were longer in period A compared to the other periods. Animals in time periods A and B were collected March-May, while period C also had animals collected June-October, precluding direct comparisons of body mass and condition (which vary markedly seasonally) for the whole sample in each period. A subset including only May data suggests that body condition did not vary between the three periods. Age distributions for A, B and C were similar, with the exception that period C had a higher proportion of animals in the 0-3 yr age group. Age at sexual maturity for males and females was similar for periods B and C, both being lower than in A. Ovulation rates did not vary among the three periods, being 0.87 0,86 and 0,91 for C, B and A, respectively. Pregnancy rate was only available for period C (0.79). Although ringed seals in Svalbard have experienced significant change to their habitat over the last 30 years, demographic parameters appear to be largely unaffected to date. More research on the reproduction, survival, density and population size are needed before firm conclusions can be drawn regarding the status of this population.

Cetacean bycatch in Indian ocean tuna gillnet fisheries

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Within the Indian Ocean, pelagic gillnet (driftnet) fisheries account for some 34% of tuna catches. We combine published bycatch sampling results from Australia, Sri Lanka, India and Pakistan to estimate bycatch rates and trends for cetaceans across all Indian Ocean tuna gillnet fisheries. Estimated cetacean bycatch peaked at about 90,000 individuals y^{-1} around 2000, but declined by about 20% since then, despite an increase in tuna gillnet fishing effort. These fisheries caught an estimated cumulative total of about 4 million small cetaceans between 1950 and 2018. These bycatch estimates take no account of cetaceans caught by gillnet but not landed, of delayed mortality or sub-lethal impacts on cetaceans (especially whales) that escape from gillnets, of mortality associated with ghost nets, of harpoon catches made from gillnetters, nor of mortality from other tuna fisheries. Total cetacean mortality from Indian Ocean tuna fisheries may therefore be substantially higher than estimated here. Declining cetacean bycatch rates suggests that such levels of mortality are not sustainable. Indeed, mean small cetacean abundance may currently be 13% of pre-fishery levels. None of these estimates are precise, but they do demonstrate the likely order of magnitude of the issue. Countries with the largest current gillnet catches of tuna, and thus the ones likely to have the largest cetacean bycatch are (in order): Iran, India, Indonesia, Sri Lanka, Pakistan, Oman, Yemen, UAE and Tanzania. These nine countries together may account for roughly 96% of all cetacean bycatch from tuna gillnet fisheries across the Indian Ocean.

High frequency hearing in grey seals (Halichoerus grypus): Do they hear 'seal-safe' pingers?

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The use of pingers have been successfully proven to reduce the entanglement of harbour porpoises in gillnets. In some areas, grey seals have learned to associate the sounds of pingers with potential food sources (fish entangled in gill nets), also known as the “dinner-bell effect” which is causing increasing conflicts in fisheries.

To overcome the problem of seals homing in on pingers, several so-called 'seal-safe' pinger brands have recently been developed. These pingers emit sounds of frequencies that are sufficiently high to presumably not be audible by grey seals. Here we test this using psychophysical methods in a pool with low ambient noise. Two seals were tested with the signals emitted by pingers at different sound levels in a staircase go-no go psychophysical paradigm. The results show that grey seals indeed can hear at least some of the sounds from pingers, with preliminary data for the Aquamark 100 pinger giving a hearing threshold of 47dB re 1µPa rms. This means that grey seals can hear these pingers at distances of several kilometers. Though the Aquamark is not designed as a 'seal-safe' pinger but a representative for traditional pingers, it is important to now investigate the seals' thresholds of 'seal-safe' pingers.

Such data are critical, especially in the Baltic, where it is important to find a solution to decrease the bycatch of the endangered Baltic harbor porpoise without increasing the seal - fisheries conflict. By understanding the auditory abilities of seals at higher frequencies, the pingers can be modified to an auditory level that is not detectable by seals but still can be heard by harbour porpoises.

Common bottlenose dolphin (Tursiops truncatus) interaction with fish farms in the Gulf of Ambracia, Western Greece.

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Fish farming is an expanding segment of marine aquaculture. This study examined the interaction between fish farming and common bottlenose dolphins (*Tursiops truncatus*) in the Gulf of Ambracia, Greece. We used data collected between 2007 and 2018 with the aim of studying if the high concentration of fish cages in western part of the Gulf had any effect on dolphin distribution and behavior. We defined two study areas: a "Control Area" in the north-western side of the Gulf and a "Fish Farm Area" in the south-west, in order to assess differences on dolphin occurrence, abundance, behavior and seasonal fluctuations between both study areas. Analysis on seasonality was limited to 2007-08, since this was the period with year-round effort. Habitat fidelity by single individual was also studied. A total of 136 sightings were included in the analysis: 104 sightings from the Control Area and 32 sightings from the Fish Farm Area, recorded in 169 and 74 days of research effort respectively. Both the probability of detecting dolphins ($U=5{,}115.000$, $P<0.05$) and group size ($U=452.000$, $P<0.05$) were significantly smaller around fish farms. Moreover, dolphin spent 22% of their time engaged in surface feeding in the control area and only 5% when around fish farms, indicating differences in foraging behavior between areas. When looking at seasonality effects, dolphins resulted more prone to interact with fish farms during winter (Kruskal-Wallis, $P<0.05$). From 28 dolphins photo-identified and resighted at least 10 times during the study period, half of them were never observed in the fish farm area. Our results suggest that marine aquaculture influences coastal dolphins distribution as well as their behavior. This information should be taken into consideration when defining ecosystem-based management initiatives measures within the Management Plan (e.g., not granting new fish farming licenses), which is currently in preparation for this Nat2000 site.

Urban Bottlenose dolphins (Tursiops truncatus): Field survey program in Italian North East Adriatic Sea.

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In 2015 Delfini Bizantini research association started a bottlenose dolphins' survey project in Italian coasts of North East Adriatic Sea. As far as we know, this area is one of the less studied of the Mediterranean basis. Despite this, preliminary data collected in few years demonstrate the constant presence of specimen of bottlenose dolphins regularly sighted during our cruises. The study area is small, extended from Goro to Marina di Ravenna. This area is theatre of strong industrial activities as hydrocarbons extraction rigs, professional fisheries and intense naval traffic. Moreover, it represents a site in which many chemical pollutants are poured from Po plan fresh water flows. The study area is divided in square transects run along the midline at a 5-7 nK speed. After the sighting, animals are approached following the ACCOBAMS cetaceans engaging rules, data reported in specific forms and photo Id identification conducted through a side picture of the dorsal fin and then elaborated with specific computer programs. The aim of this research is to collect scientific data on the abundance, population structures and behaviour of bottlenose dolphins in the study area, through the years, to define if there

are environmental or anthropic factors that could interfere with the wellness and the regular presence of dolphins in the Adriatic basis. First data analysed show a different distribution of the subject sights during the months of our field campaigns. This could be linked to numerous factors including fishing lay-off periods, research efforts, presence of calves and weather and sea conditions. Further studies and researches on field need to be conducted to confirm these hypothesis, but these preliminary results are essential to raise public awareness on the necessity to respect the marine ecosystem, to build predictive studies on the future conservation of bottlenose dolphins and to onset concrete actions to protect the species in this geographic area.

Protection and valuation of whales and dolphins by the local community in the municipalities of Anakao, Soalara Sud and Saint Augustin, ToliaraII, south-west of Madagascar.

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For decades, the communities of fishers of the three municipalities of Anakao, SoalaraSud and Saint Augustin in the south-western region of Madagascar were hunters of cetaceans. Socio-ecological interviews indicated that thousands of cetaceans were caught there for local consumption and sale between 1970 and 2000. In 2008, the Fikambanana Miaro nyTrozona sy Fesotra (F.M.T.F), or Association for the Protection of Whales and Dolphins, was created after a series of workshops on the conservation of marine mammals that we carried out jointly with the Madagascar National Parks. The goal of this association is to protect and to increase the value of marine mammals through community-based whale watching and the application of the local laws. Since 2010, the hunters of the cetaceans have been trained to become tourist guides and take whale and dolphin watchers on the water using traditional and motorized dugout canoes. As a result, the number of guides rose from 6 in 2010 to 34 in 2018, and the number of whale watching tourists from 143 in 2010 to 1568 in 2018. The price varies from 40000 Ariary (11,76Euros) to 60000 Ariary (17,65 Euros) per tourist according to the location and the duration of the excursion. All local laws related to hunting and codes of good conduct for whale watching are written in the local convention or Dina which is strongly respected by the local communities. Recognizing the advantages of these activities, the local communities which previously were cetacean hunters, are now becoming strictly protectors of cetaceans.

Higher levels of organohalogen contaminant and mercury levels in seal-eating killer whales (Orcinus orca) than fish-eating killer whales in northern Norway

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High levels of organohalogenated contaminants (OHCs) in killer whales *(Orcinus orca)* have raised concerns about individual health and population viability. Mercury (Hg) also has harmful effects on marine mammals, but levels are underreported in killer whales. OHCs and Hg biomagnify in food chains, and OHC levels are highest in killer whale populations specialising on high-trophic prey, such as in the transient populations in the north east Pacific. Killer whales in Norway have long been assumed to specialise on Atlantic herring (*Clupea harengus),* and toxicological risk assessments for this population in Norway have relied on the OHC levels recorded for only nine herring-eating killer whales sampled in 2002. However, there is recent evidence that a subset of killer whales in Norway specialise on seal prey. Our study quantified and compared the OHC levels in blubber, and the total Hg levels in skin, of seal-eating and fish-eating killer whales from northern Norway. Biopsy samples of 31 killer whales, known from photo-identification studies, were collected from July 2017 to August 2018. The sum of polychlorinated biphenyls (ΣPCBs) in the blubber exceeded risk assessment thresholds in 100% of the seal-eating whales (n=7) and 58% of the fish-eating whales (n=26). Total Hg levels in liver, extrapolated from levels in skin, exceeded the risk assessment threshold in 40% of seal-eating and none of the fish-eating whales. Levels of all OHCs and total mercury were higher in seal-eating killer whales than fish-eating whales. Our study is the first to quantify the levels of OHCs and Hg in seal-eating killer whales from Norway, and illustrates the importance of acknowledging intra-population dietary preferences of a species when assessing its risk to contaminants.

Preliminary study on the potential re-organisation of new social groups of long-finned pilot whales (Globicephala melas) in the Strait of Gibraltar.

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The Strait of Gibraltar constitutes the unique communication channel between the Mediterranean Sea and the Atlantic Ocean. The complex geomorphology and oceanographic conditions of the area sustain high levels of food sources for resident populations of several cetacean species, among those the long-finned pilot whale (*Globicephala melas*). This species present a sophisticated social structure, living in cohesive social groups known as pods. These pods are normally characterised by their long-term duration and can be formed by many individuals, which can remain in the group during their entire lifetime. The aim of this study is to describe any changes in the organisation of the observed pods along time at intra- and inter-annual scales. Individual pilot whale dorsal fins were photographed and analysed between Spring 2012 and Autumn 2018. These pictures were collected by biologists-guides onboard the whale watching boats of Turmares Tarifa following the same photo-ID protocols throughout the entire study period. The connectivity among different individuals was assessed in order to reveal any occurring restructuring and consequent formation of potentially new social groups. The preliminary results showed evident and persistent disaggregations and interchanging of individuals in a time where they are supposed to belong to concrete, particular pods. Our findings demonstrate that an approach based on long-term photo-ID by opportunistic whale watching platforms can assist traditional scientific research for the monitoring of cetacean population dynamics and social structure in the Strait of Gibraltar.

Autonomous detection of humpback whales - migration and distribution in relation to Norwegian spring spawning herring.

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Humpback whales (*Megaptera novaeangliae*) até known to travel through the Norwegian Sea between their arctic summer feeding areas and low latitude breeding grounds. Traditionally, it is believed that they do not feed during migration. We use passive acoustic detections from a Seaglider™ (Kongsberg) autonomous vehicle equipped with a JASCO AMAR G4 hydrophone and a fixed hydrophone (Ocean Sonics iListen HF™ at the Lofoten-Vesterålen (LoVe) Cabled Ocean Observatory ti investigate detection and timing differences between the two platforms in January to April 2018, and in relation to ARGOS tracking data from that year. Detections were also assessed in relation to the distribution of the herring fishery and migration routes southwards towards their spawning grounds. The two platforms recorded over 2856 hours of acoustic data at two different regions: LoVe on shelf and the Seaglider at the shelf break, distanced about 300 km. Calls collected by the Seaglider were usually within the 150-500 Hz range and generally lasted less than 2 seconds. In LoVe, on the other hand, a much wider vocal repertoire of sounds was registered, which included the humpback whale song. In addition to signal-type differences, we observed significant changes in detection rates between the two platforms throughout the study period. Detections from LoVe decreased significantly in late February, while the Seaglider continued to receive calls from mid-March to mid-April. Furthermore, satellite tracking showed that the whales follow the shelf break for a period of time before continuing towards their breeding grounds. Both areas were occupied by large densities of herring, particularly in February, though some schools may remain until early spring. This work shows that the Norwegian Sea represents more than a passage route to the whales, which remain in the area until early spring following a migratory pathway driven by prey distribution, beyond traditional assumptions of whale migratory behavior.

Habitat use and behavioural ecology of the Mediterranean monk seal (Monachus monachus) in Samos Island, Greece.

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The estimated global number of Mediterranean Monk seal (*Monachus monachus*) individuals left is around 650, with the largest population located in the Eastern Mediterranean Sea.

Samos is a Greek island located in the north-eastern Aegean Sea where the presence of Monk seals was investigated in this study. Daily land surveys were conducted in Mykali bay to record their presence and behaviour. Data collection started in April 2018 and is still ongoing. Habitat mapping and fish identification snorkelling surveys were also carried out in order to have a complete environmental assessment. In addition, stranding and sightings data occurred on Samos were collected from January 2017.

During the land surveys, a total of 5 sightings was recorded (Encounter Rate = 2.66%). The two main behaviours observed were Surface Swimming (24.75%) and Feeding (22.73%) (p-value < 0.01). The predominant substrates of the study area were Cobbles (60.35%) and Sand (24.20%) (p-value < 0.01). Sparse patches of the seagrass species *Cymodocea nodosa* (4.05%) and *Posidonia oceanica* (3.05%) were also noted. The most encountered fish were *Diplodus sargus* (14.67%) and *Diplodus annularis* (14.39%) (p-value < 0.01). The local community reported 18 sightings, 7 of which were in Mykali, and 5 stranding around Samos.

The presence of Monk seals occurred around the island in different habitats without noticeable preference for caves. The recorded behaviours and the fish species suggest that the study area may be a feeding ground for *M. monachus*. This study highlights the urgency to focus on different key habitats for the conservation of this endangered species rather than only on breeding caves. Samos Island stands out as an important area for the Mediterranean Monk seal but further research is necessary to establish the appropriate conservation measures.

Photogrammetry supports tag-derived tissue density as a proxy for body condition: Seasonal and locational changes in body condition of humpback whales on their feeding grounds.

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It is essential for animals to accumulate sufficient reserves for survival and reproduction. For diving animals, there may be a trade-off between energy accumulation and locomotion cost because large amounts of low-density lipids could lead animals to deviate from neutral buoyancy, which is assumed to minimize cost-of-transport. We examined body condition of humpback whales using 1) animal-attached data-loggers and 2) aerial photogrammetry in two feeding grounds: June-September in Canada and May-January in Norway. Tissue Body Density (TBD) and diving air volume were estimated for 58 individuals from accelerations during decent and ascent glides. The Length-Standardized Surface Area Index (LSSAI) of 55 animals was calculated from overhead photogrammetry images. LSSAI and TBD correlated negatively (p=0.035) for 20 whales where both indices were available, indicating animals with greater surface area had lower TBD (greater lipid-stores). Seasonal changes in body condition and their relationship to life-history traits (sex, maturity and breeding status) were assessed in a hierarchical model that utilized both LSSAI and TBD as observations of underlying TBD (uTBD). The uTBD decreased over the feeding season (-1.8 kg m^{-3} per 100 days), indicating lipid-stores increased as expected. It was lower for pregnant females (-4.2 kg m^{-3}), indicating greater lipid-stores compared to adult males. uTBD was greater in Norway than Canada (+4.8 kg m^{-3}) in the early feeding season, possibly due to lower lipid-stores following a longer migration. uTBD in the late feeding season remained greater than that of sea water (Canada, 1034.3±4.6 kg m^{-3} ±SD,

n=15 whales; Norway, 1035.8±4.0 kg m^{-3}, n=13), indicating negative buoyancy. Whales could achieve neutral buoyancy while migrating at shallow depths, enhancing locomotion efficiency, using their diving air volume (37±1.7 ml kg^{-1}, ±95% credible interval). This study highlights the benefit of using two different methods to quantify the body condition of free-ranging whales.

Mediterranean monk seal populations characterization through a permanent monitoring system

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Among all the Mediterranean monk seal populations still surviving in the world, only the demographic parameters of the Cabo Blanco (Mauritania/Morocco) colony have been obtained accurately. Based on the methodology used, a monitoring system was developed to obtain the demographic parameters of any other monk seal population. The system is based in the permanent implementation, during several years, of autonomous monitoring systems, based in phototrap cameras, in the main monk seal caves used by the population. The systems register the presence/absence of the seals in the caves on a every hour basis, and the pictures obtained allow to individually identified the animals through their natural marks. The method has been tested at Madeira archipelago where 25 systems were installed at 19 caves of Madeira and Desertas from 2012 to 2017. A total of 481.070 pictures were obtained, 9.835 of them with monk seal individuals presence, and 2.748 suitable for their individual identification. The analysis allowed to capture and recapture all the animals of the population and build up a catalog. Most of the animals are recaptured every year, resulting in an annual recapture rate of 0.99, and a mean of 9.8 annual recaptures for each individual from 2014 to 2017.

This intensive and permanent control has allowed to monitor animals from birth to adulthood, building up the life history of every animal and determine yearly, the population size, age and sex structure, reproductive parameters, mortality rates of the different age categories and cave use patterns. The positive results of the methodology, demonstrate that it could be used to describe the main demographic parameters of any Mediterranean monk seal population, providing high quality and accurate information for protected areas and wildlife managers, to better design or adapt focused conservation measures targeting specific age or sex categories and their threats.

Beyond the vegetation consumed by manatees in the Caribbean: Invertebrates and debris found in digestive contents and faeces.

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Manatees have been described as generalist-opportunistic herbivores, with a diet composed by a great variety of plant species. However, the incidental consumption of hydrozoa, invertebrates and inorganic elements such as plastics has also been reported. Our goal was to assess the incidental consumption of animals and other elements by Antillean manatees (*Trichechus manatus manatus*) in the Caribbean of Mexico and Belize. A total of 93 feaces were collected (30 from free-ranged, and 63 from captive manatees among 2012 and 2018); also, 15 digestive contents of seven stranded-dead were analyzed. Each sample was washed, sieved, and stored, followed by separation/identification observation in an stereoscopy microscope at 4-20x magnification. The results are presented as the proportion of samples with presence of objects. Free-range manatees presented invertebrates (mollusks) (6.7%), foraminifera (13.3%), sponges (11.1%), undetermined invertebrate species (2.2%), feathers (2.2%), plastic (6.7%), glass (2.2%) and cloth (2.2%). Additionally, we report 4.8% of plastics in faeces from captive manatees. These elements, both organic and inorganic, are presumed to be incidentally consumed by wild manatees. The presence of inorganic elements (such as plastic) in the feaces of wild manatees is an important signal to be evaluated and deserves further monitoring, since it is well known that some plastics could have an important impact on health and survival of the aquatic fauna. Nevertheless, more research is

necessary to precise the possible effects that these inorganic particles have on manatee health.

Sleeping behaviors of captive Commerson's dolphins (Cephalorhynchus commersonii)

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Cetacean sleep is studied with the eyes open and closed as the main index. However, the faces of commerson's dolphins are black, so it is difficult to check the status of the eyes. Therefore, to our knowledge, the detailed behavior of sleeping there has not been elucidated. When the amount of activity declines was observed as sleep time, only 14% of the day could confirm sleep. Since this is less than one-third of that of other cetaceans, it has been suggested that Commerson's dolphins may be asleep even in the active state. Sendai Umino-Mori Aquarium is the only environment in the world where the condition of the eyes of Commerson's dolphins can be checked. Therefore, the aim of the present study was to investigate the above hypothesis and attempt to clarify the detailed sleep behavior of Commerson's dolphins. A total of 290 hours of observation was conducted from 06:00 to 18:00 every month about three dayson three Commerson's dolphin family members. Sleep was defined as the eyes being closed for more than 10 s . Swimming speed, breathing frequency, swimming route, and sounds were recorded simultaneously. In total, 1720 sleep episodes were recorded. The results showed that the average swimming speeds during the waking and sleep states were 1.17 and 1.19 m/s, respectively, showing no significant difference. Furthermore, no significant difference in breathing frequency was observed. On the other hand, clear sleeping characteristics were confirmed in the swimming route and sounds. The swimming route was limited to repetitive loops around a large circular course along the tank wall, and the average number of sounds decreased to one-quarter of those during the waking state. These results support the above hypothesis and suggest that Commerson's dolphins remain in the same physical condition during both waking and sleeping states.

Just pissing in the wind? Aerial urination in river dolphins in Brazil.

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For many mammals, scent marking via urine spraying facilitates mate selection, marking territories and communication with conspecifics. The chemicals in urine may transmit information about the state of the urinator (e.g., physiological). However, for cetaceans, olfaction is not a sense known to be used while gustation is poorly studied. An unusual behavior of urinating in the air by botos (*Inia geoffrensis*) in the Tocantins River (central Brazil) appears to be unique to cetaceans. Aerial urination begins with an animal slowly positioning itself upside down and extruding and exposing his penis above the water. The stream of urine may reach almost one meter into the air and arcs anteriorly. When another individual is present (categorized as 'receiver'), it remains nearby the urinator and lifts its rostrum in the direction of the stream or actively pursues the urine stream. In some occasions the receiver will remain underwater but just below the stream. Behavioural data were obtained during land-based surveys where the duration of each aerial urination event was recorded as well as the presence of receivers. From September 2014 to March 2016, 22 aerial urination events were recorded during 152 hours of sampling (0.14 events/hour of sampling). About 68% occurred in the presence of at least one receiver. The mean duration was 27 seconds with the longest event lasting 58 seconds. No apparent seasonality in this behavior was observed. All aerial urination events involved males (thus far, no females have been observed partaking in this behavior). Because botos also performed this behaviour in the presence of others, which actively pursued the urine stream, it is likely that aerial urination has a socialization or communication function. Botos possess bristles on their rostrums, which are thought to serve a sensory purpose (haptosense) and so may play an important role during aerial urination.

Increase of cetaceans' ship strikes in the Canary Islands

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The Canary Islands is an archipelago composed of seven main volcanic islands, located in the northwest of Africa. It is one of the richest areas for cetacean biodiversity in the Northeast Atlantic, with 30 species identified. Strikes between vessels and cetaceans have become an issue of concern in the last decades due to an increase of the number and speed of ships. Areas with high cetacean diversity and high maritime traffic overlap have been identified as hot spots as ship strikes may compromise the population status of some cetacean species in those areas. In Europe, these areas include the Ligurian Sea, the Helenic Trench and the Balearic Islands in the Mediterranean Sea, the Strait of Gibraltar, and the Canary Islands. International but mainly inter-island ferry traffic in the Canarian waters has increased considerably in the last years including normal ferries, fast ferries, and high-speed ferries. According to the Canary Islands Cetacean Stranding Network data, ship collisions have affected a total of 81 cetaceans belonging to 12 species in the last 20 years (7 misticetes and 74 odontocetes: 5 short finned pilot whales, 10 pigmy sperm whales, 11 beaked whales, 46 sperm whales and 2 small delphinids), 33 of these cases were confirmed by forensic studies. The average per year of ship strikes in this period (1999-2018) is 4.5, 0.37 per month. During the months of January to April of 2019, 4 confirmed cases affecting to sperm whales (3) and Bryde´s whale (1), and another possible case, affecting a short-finned pilot whale, have been reported. This increase in ship strikes (from 0.37 to at least 1 per month) in the Canary Islands is coincidental in time with the introduction of new high-speed ferry routes, raising the concern of the impact of ship strikes in the conservation of sperm whales.

Modelling habitat suitability of low density cetaceans species in the Mediterranean Sea

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The conservation of low density cetacean species is extremely challenging. In the Mediterranean sea, Risso's dolphin (*Grampus griseus*), Cuvier' Beaked Whale (*Ziphius cavirostris*), and long-finned pilot whale (*Globicephala melas*) are listed as 'Data Deficient' in the IUCN Red list of threatened species, highlighting the lack of information about their abundance, preferred habitat, distribution and trends. For these species, information about preferred habitat and the detection of eventual changes in distribution is essential for their conservation. The Fixed Line Transect Mediterranean monitoring Network (FLT MedNet) is operating in the Mediterranean basin since 2007, regularly collecting cetaceans' data along fixed trans-border transects during all the seasons. The high frequency of surveys allowed recording quite a large number of sightings also of the more elusive species such as *Z. cavirostris* (111), *G. melas* (33), *G. griseus* (65). We used this homogeneous dataset to model suitable habitat of the three more rare species by means of Maximum

Entropy model, using as background file the area of western Mediterranean and the Adrion region were the surveys were performed. The long term FLT MedNet data were used for building the model while data from the more recently activated FLT MedNet routes and the Mediterranean dataset recorded by ORCA were used for the model validation (58 records). Distribution of sightings was also investigated during the two time periods of the Habitat reporting (2007-2012, 2013-2018) using the Kernel density estimator to highlight potential shifts in the core areas of occurrence. Based on AUCs, validation data, and well known sites of species presence, the model results showed high performance over the large basin wide scale. Important changes in distribution were highlighted for some species such as Risso's dolphin and long-finned pilot whale.

Who are we? A demographic survey of marine mammalogists.

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In response to the growing recognition of the importance of enhancing diversity and feelings of inclusion within scientific communities, in late 2018, the ad-hoc Diversity and Inclusion Committee of the Society of Marine Mammalogy (SMM) conducted a demographic survey of the field of marine mammalogy. This anonymous survey was designed to document the composition of who is currently working in the field, to identify their concerns, and to solicit suggestions for how SMM could help the community. Invitations to participate were sent to all current and past SMM members as well as posted through several social media outlets, resulting in 879 responses. Although the female:male ratio of responses was approximately 2:1, across most age groups, a higher percentage of males reported having doctorates. Across several demographic measures, younger respondents were more diverse. Approximately 50% of respondents considered the United States as their country of birth, primary citizenship, or current residence, with the next highest number of respondents listing Canada (6%). Overall, 78 countries were represented in at least one of these three categories. Respondents from Latin America, the Caribbean, the Middle East, and Africa had the highest rates of citizenship or residency in a country other than their country of birth. English was the primary language for 68% of respondents, and Spanish the second most common (10%). Some major themes from comments included requests for accessibility of all types, events such as mixers or special publications that highlight marginalized groups, outreach and support for people in underprivileged communities, more financial accommodations, and support for parents at conferences. We thank all who participated in this survey and will use their comments as a baseline for monitoring demographic change in the field and to guide recommendations for SMM as it moves forward in creating a more inclusive and diverse community.

Community marine reserves benefit both fishermen and pinnipeds.

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Improving commercial stocks is the main goal of community marine reserves, which are implemented and managed by fishermen. Fishing areas surrounded by pinniped rookeries often show conflicts between these predators and fishermen, and it has raised the question if these reserves are effective. To answer it, we conducted a survey of fish biodiversity and biomass in four islands in the Pacific side of Baja California, Mexico. These islands are subject to exclusive concessions to small artisanal fishermen cooperatives, two of which have implemented marine reserves, Natividad eight years ago and San Jeronimo a year before surveys. There are important rookeries of California sea lion (*Zalophus californianus*) in three of them and Pacific harbor seal (*Phoca vitulina richardii*) in all four. We did a general linear mixed model considering all fish species and another filtering by potential prey for each species of pinniped using known prey species reported in the literature. Both the general fish model and the model of potential prey of California sea lions showed that Natividad (oldest reserve) has the highest fish biomass and the pattern is shown but inside and outside of the reserve polygons. The model for potential prey of harbor seals did not showed significant effects on biomass. Species richness and fish biodiversity was also higher in

Natividad. These results indicate that reserves increase overall fish diversity and biomass, despite the presence of top predators, and even increase their potential prey in the case of sea lions. An ecosystem with higher biodiversity and biomass tends to be more resilient, therefore, community marine reserves may also help improve the resilience of marine mammals to climate driven phenomena, as well as maintaining a healthy marine ecosystem for the benefit of both pinnipeds and fishermen.

Seals as sentinels of antimicrobial resistance genes in UK waters: A preliminary screen to test for temporal changes in gene detectability.

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Antimicrobial Resistance Genes (AMRG) are a pressing concern to human and animal health. These genes are ubiquitous in the environment, and can spread rapidly because of human and industrial waste, agriculture, and aquaculture. Many of the waste products from these processes eventually make their way to ocean waters, providing AMRG ample opportunity to disseminate. Pinnipeds are apex predators in UK waters, sampling the entirety of the water column when they forage. These animals regularly return to hall out on shore, allowing us to examine what they have eaten in an accessible manner, and providing a way to look for potential upstream resistance. Previous studies have examined a limited and biased number of known pathogens for AMRG, resulting in a poor understanding of which specific AMRGs are prevalent in non-pathogenic strains. AMRG have the capacity to be transferred between bacteria, suggesting that even genes that are not currently found in pathogenic bacteria can be used as an early warning of the potential for transfer to pathogens. This study uses a novel medium throughput screen developed as part of a larger project to test for the presence of AMRG independent of the bacteria they are found in. This screen was used to analyse faecal matter from seals for common antimicrobial resistance genes using PCR and gel electrophoresis.
We analysed samples at time of collection, two months after collection, and six months after collection respectively to assess the effect of storage duration on the probability of detection of environmentally important AMRG, allowing us to determine if previously collected samples can effectively be used as a part of a larger study. Analysis of grey seal gut resistome provides much needed information about possible time related degradation of these genes in previously collected samples for future work creating a baseline of AMRG in UK waters.

Environmental influences on breeding biology and pup production in Australian fur

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Knowledge of the factors which affect the breeding biology of a species is crucial to understanding how environmental variability impacts population trajectories and enables predictions on how species may respond to global change. While its population is still recovering from the over-exploitation of the commercial sealing era (currently estimated at 50-60% of pre-sealing levels), the Australian fur seal (*Arctocephalus pusillus doriferus*, AUFS) represents the greatest marine predator biomass in south-eastern Australia. The region is currently one of the fastest warming oceanic regions in the world and is expected to experience substantial changes to current regimes that will impact the abundance, distribution and diversity of prey species. Therefore, understanding the environmental factors that influence the breeding of the species is urgently needed to predict how it, and the prey populations it depends upon, may respond to anticipated ecosystem changes. The present study investigated annually the timing of breeding and pup production in AUFS on Kanowna Island, northern Bass Strait, between 1997 and 2018. During this period, pup production varied greatly (1386-2574) but sustained an overall increase of 1.3% per annum. Median and spread of pupping dates varied by up to 9 d and 10 d, respectively. Median birth date was earlier in years when adult female body condition (measured during pregnancy) was greater ($r^2 = 0.33$, $P < 0.05$), which was negatively correlated to sea-surface temperature ($r^2 = 0.30$, $P < 0.05$) within Bass Strait. Pup production was positively correlated to summer (before implantation) and winter (active gestation) SOI ($r^2 = 0.38$, $P < 0.02$ in both cases). Higher SOI periods are associated with stronger zonal winds, which have been shown to influence prey availability. With SOI and regional winds forecast to increase in the coming decades, these results suggest the AUFS population may experience advantageous conditions and continue to grow.

Estimating beaked whale density from passive acoustic recordings

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Beaked whales emit frequency-modulated clicks that facilitate their detection using passive-acoustic monitoring (PAM). Here we provide an independent validation of the precision of PAM estimates from acoustic point sampling. El Hierro (Canary islands), holds year-round coastal populations of Cuvier's (*Ziphius cavirostris*) and Blainville´s (*Mesoplodon densirostris*) beaked whales. Here, acoustic monitoring can be combined with land observations to optimize visual detection probability. We evaluate acoustic parameters, including click rate and detection probability, required for density estimation and use these to calibrate the accuracy of density estimators by using it in combination with reliable ground-truth density from visual surveys. We recorded simultaneous observations from double-platform land-based surveys and acoustic detections from drifting SoundTrap recorders (200 m depth, 144 kHz fs). Density was estimated using a PAM cue-counting method. Click production was estimated from DTAGs and modeled to assess its variation due to social parameters. Click detection probability was obtained from DTAG and PAM deployments and modeled to assess the effect of click detector characteristics. Mark-recapture and distance sampling methods were used to estimate density from visual data. 32,870 beaked whale clicks were identified in 206 recording hours, 68% [95% CI 61, 75] of which were classified as certain beaked whale clicks. Click rate averaged 0.39 clicks$\cdot s^{-1}$ [CI 0.32, 0.50]. Acoustic detection probability was 0.15 (CV 0.25). The resulting animal density was 4-10 beaked whales [CI 2.7-5.5]-[CI 8.2-12.4] *CV* 14-18%, depending on whether the uncertain clicks were considered or not. Estimated density from visual surveys was 4 beaked whales [CI 1.2-6.7] CV 24%, which falls within the acoustic estimate's CI. These results have implications not only on the long-term monitoring of potential impacts of naval activities in these taxa, but also on the evaluation of the number of beaked whales at risk in order to minimize possible accidental exposures during real-time mitigation situations.

Fat embolism and sperm whale ship strikes.

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The Canary archipelago is a geographical area with an important overlap between cetaceans and maritime traffic. Among different species, sperm whales (*Physeter macrocephalus*), currently listed as a vulnerable species, are the most affected by ship strikes in the Canaries. Subcutaneous, muscular and visceral extensive hemorrhages, and hematomas, indicate unequivocal antemortem trauma. However, when carcasses are highly autolyzed, distinguishing if the trauma have occurred ante- or postmortem can be very challenging. In other species, the presence of fat emboli within the lung microvasculature has been extensively used to determine a severe "in vivo" trauma. We hypothesized fat emboli detection could be a reliable and accurate forensic tool to assess ante-mortem ship strikes in stranded sperm whales, even when carcasses present an advanced autolysis. In the current study, the presence of fat emboli was evaluated, using an osmium tetroxide (OsO4) based histochemical technique, in the lung tissue of 24 sperm whales, 16 of them with evidence of ship strike, stranded and necropsied in the Canaries between 2000 and 2017. About 70% of them presented an advanced autolysis. Results revealed the presence of OsO4-positive fat emboli, with varying degrees of abundance and distribution, in 13 out of the 16 sperm whales with

signs of ship strike. The main conclusions were: 1) the usefulness of fat detection as a diagnostic tool for "in vivo" trauma, even when carcasses presented and advanced autolysis, and/or tissues were kept in formaldehyde for long periods of time; and 2) that, in the 18-year period studied, at least, 81% of the sperm whales that presented signs of ship strike were alive at the moment of the strike and died subsequently. This information is highly valuable in order to implement proper mitigation measures in this area.

Occurrence of allo-suckling and non-filial mother-pup interactions in a declining harbour seal population.

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Fostering and allo-suckling have been reported in numerous mammal species, including phocids. Although the reasons behind these non-filial behaviours are poorly understood, it is suggested that fostering can represent costs and benefits to mothers and pups. Here we document non-filial interactions observed at harbour seal (*Phoca vitulina*) haulout sites in Orkney (Scotland), a region where harbour seal numbers have declined by 85% since the year 2000. Photo-identification data were collected between 2016 and 2018, on a daily basis during the pupping season, at four haulout sites. Mum-pup pairs were identified from the unique pelage patterns, and field observations of filial and non-filial interactions documented. Non-filial interactions (NFI) were classified as aggressive (female reacts aggressively to an alien pup), wanted (female interacts positively with an alien pup), and allo-suckling (female suckles an alien pup). NFI were observed throughout all pupping seasons, in 22, 29 and 57 separate occasions involving 29-49% (n=13-20) of females that had a pup that year. Allo-suckling was the most commonly observed behaviour, occurring in 46-76% of the documented NFI, involving 20-39% (n=9-12) of all identified mothers and 20-50% (n=9-18) of all identified pups each year. Females suckled 1 to 4 alien pups in a season. Eight females suckled alien pups in different years. Allo-suckling of assumed abandoned (i.e. starving) pups was observed 1-2 times each year; all other allo-suckling events involved 'healthy' pups also suckling from their mothers. In contrast, allo-suckling was not observed in other regions of Scotland (Isle of Skye and Kintyre) where photo-identification data were also collected as part of the same study. Observations at one of the study sites in Orkney from 1982 document "beggar pups", suggesting allo-suckling might be independent from the current declining population trajectory. However, allo-suckling could have added costs for females if adult survival and/or recruitment are already compromised.

Bottlenose dolphins in the Western Ligurian Sea (Mediterranean Sea): Preliminary study on social structure and residency patterns.

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In recent years, a relative increase of common bottlenose dolphin *(Tursiops truncatus*) presence has been observed in the Western Ligurian Sea (Mediterranean Sea) by fishermen, whale watching companies and observations from land. Purpose of this work is to provide the first analysis of the social structure and residency patterns of this population. Data were collected during 67 dedicated daily boat-surveys, conducted from April 2018 to March 2019, in all 4 seasons. A total of 31 sightings was reported and 66 dolphins were photographically identified and re-sighted up to 14 times (average = 6.4 times). In the analysis, only dolphins with 3 or more recaptures were considered, corresponding to 39 individuals. Social structure was investigated quantifying the associations among individuals, through the half-weight index (HWI) and estimating the temporal pattern of association. Residency index was calculated for each dolphin as number of recaptures per total surveys and their residency patterns as dolphins' presence or absence in the 4 seasons. Analysis showed that this community is organised in 4 subgroups with rapid association patterns (median time interval: 2 days) and 2 levels of acquaintances. Association values was low (0.2-0.4) for most dolphin pairs, except for few strongly associated couples (HWI>0.8). The residency indices ranged from 0.04 to 0.21, 38% of dolphins showed an index greater than 0.10. Dolphins could be seen year-round; however, 48% of the individuals were encountered in 3 seasons and could be classified as year-round residents. Only 5 individuals were encountered in 4 seasons; they belonged to the same social unit and their HWI values were greater than 0.5. High values of both residency and association indexes characterised only one of the 4 social subgroups. A future long-term monitoring will contribute to increase the knowledge about this dolphin community and will

help develop management and conservation strategies.

Re-sight occurrence and frequency of satellite tagged humpback, fin, and sperm whales off Virginia, USA

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Satellite tagging studies provide opportunities to track animal movements following an initial observation during which a tag is deployed. Often times, those animals are not re-sighted post-tag deployment, leaving tag site healing, and even survival, as mostly unknown variables. Medium-term Wildlife Computers satellite tags (SPOT6, SPLASH10, and SPLASH10-F) in the LIMPET configuration were deployed on humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), and sperm (*Physeter macrocephalus*) whales off the coast of Virginia between December 2015 and March 2019. Forty-nine tags were deployed on humpback whales, 15 tags on fin whales, and 20 tags on sperm whales. Five humpback whales and one sperm whale were tagged twice each during different years. Thirty-two of 45 (71.1%) individual tagged humpback whales, 3 of 15 (20.0%) fin whales, and 3 of 19 (15.8%) individual sperm whales were re-sighted after tagging. For animals that were re-sighted, individual humpback whales were re-sighted up to 10 times after tagging (mean=2.7), fin whales were re-sighted up to 2 times after tagging (mean=1.7), and sperm whales were re-sighted once after tagging (mean=1). Re-sights occurred 1-774 days apart (mean=167; median=33) for humpback whales, 100-356 days apart (mean=269; median=353) for fin whales, and 9-401 days apart (mean=250; median=343) for sperm whales. Re-sights occurred both when the tag was still attached and after the tag had been shed. Follow-up photos of the tag site were taken whenever possible to assess tag site healing. Due to the more accessible nature of nearshore waters, re-sightings of humpback whales occurred more frequently than those of fin and sperm whales, which were observed further offshore, typically in the mid-shelf area for fin whales and in deep water past the continental shelf break for sperm whales. These observations can provide valuable opportunities to assess tag site healing and can also provide insight on survival for these large whales.

Acoustic identification of cetaceans using deep learning techniques

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Modelling cetacean population dynamics is paramount for effective conservation and management. Cetaceans are also prime candidates for modelling ecosystem change under the ecosystem sentinel concept. Moreover, robust population data can aid in assessing the risk presented by anthropogenic activities. One methodology for cetacean research utilises passive acoustic monitoring (PAM) to investigate cetacean occurrence and behaviour ecology. Advantages of PAM include: it is less expensive and labour intensive compared to visual methods; and can record data over long temporal scales. Due to the large volumes of data collected and stored in PAM systems, there is a need for effective, automated solutions that can detect and classify cetacean vocalisations. Current technologies provide identification of some cetacean species using echolocation clicks and whistles, such as C-POD and ROCCA. However, they do not harness deep learning techniques and/or use signature whistles to identify individuals within a species, which could allow for estimating abundance and monitoring of individual dolphins' occurrence and residence patterns. In this study, through collaboration between computer scientists, engineers, and marine biologists, methods have been developed which utilise digital signal processing and deep learning techniques to detect and classify individuals within dolphin species. The system in development detects the possible presence of a cetacean whistle using Goertzel's algorithm by considering a ratio between the produced whistle and background noise frequencies. Once detected, the audio is segmented to contain only the whistle and represented as a spectrogram. This is passed to a Convolutional Neural Network (CNN) that has been pretrained to identify signature whistles of individual *L. albirostris*. The CNN uses the spectrogram to predict matches between new and previously recorded and classified signature whistles allowing for the use of capture-recapture analyses. Initial work has provided promising results, providing evidence of *L. albirostris* producing signature

whistles similar to those described in *Tursiops truncatus*.

When the whales win, everyone wins: Employing participatory research to create a culture of environmental stewardship in Guerrero, Southwest Pacific Mexico.
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Guerrero, one of the most biologically diverse and understudied states in México, hosts 16+ marine mammal species and a once thriving fishery. Poverty, corruption, pollution and a lack of education and opportunities are leading to environmental destruction. As of 2013, awareness of and protection measures concerning marine mammals were non-existent, despite the predominance of marine-based tourism and commercial fishing methods known to be deleterious to marine mammals.

Between 2014-2019, we collaborated with Guerrero communities to identify the potential for marine mammal-based ecotourism activities through a first-ever, 1600-hour participatory humpback whale survey. It was our goal to cultivate a shift toward marine conservation through this survey in tandem with capacity building; education; outreach; ecotourism market development; and fishermen's learning exchange programs.

Advances included: an 85% increase in awareness and investment in marine mammals; a community-supported safe whale watch program (75 guides trained); development of ecotourism market and activities to alleviate pressure on the fishery and motivate environmental stewardship; a voluntary 30-member stranding network; a 100+ fishermen marine mammal spotting network; and groundbreaking humpback whale survey results.

The fishery continues to decline and we now know that marine mammals are threatened in Guerrero; many species present with pollution-borne diseases, emaciation and anthropogenic scarring and some species sighting rates have declined by more than 75% since 2014.

However, because of our transparent and inclusive approach, the community has developed an interest in restoring their marine environment and the potential for conflicts between stakeholders has been reduced.

Community-requested next steps underway include: Year-round immersive nature programs; strengthening ecotourism market supply and demand; student-run dolphin studies; and a community-developed marine management plan, including marine mammal monitoring.

Nesting Instinct: Distribution and habitat use of humpback whale mother-calf pairs in the southern Pacific coast of México.
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North Pacific humpback whales (*Megaptera novaeangliae*) feed in mid- and high-latitude waters and overwinter in the tropics. While winter habitat use in Hawaii and Northern Mexico has been well-documented, data regarding potential breeding, nursing and calving ground sites in Southern Mexico is scarce.

Whales of Guerrero (WoG) is a non-profit organization focused on humpback whales and other marine mammals on the southern Pacific coast of Guerrero, México. With a peak presence of whales from January to March, Guerrero has been confirmed as a nursing and calving ground, as well as a breeding site and migration corridor for *M. novaeangliae*.

1688 effort hours of boat-based surveys were conducted between 2014–2018. Humpback whale mother-calf pair sightings (n=151) were divided into four group types: mother-calf (n=116), mother-calf and escort (n=28), mother-calf and two non-competing whales (n=6) and mother-calf with 3+ competing whales (n=1). Models were fit to estimate and predict the distribution of the four groups of humpback whales in Guerrero, along with environmental parameters that could influence it. Distribution of mother-calf pairs were mostly related to depth and proximity to the coastline. Prediction maps met most of the sightings and showed various areas of distribution in the area.

Mother/calf pairs were resighted up to five times seasonally, observed nursing and resting in shallow bay waters. Calf size and visible fetal folds also support the thesis that this region is a calving ground.

Since Guerrero's humpback whales are more similar to the Distinct Population Segment (DPS) of Central America (listed as endangered; n=411 individuals) than the Mexican DPS (listed as threatened; n=3624), these results provide meaningful information regarding North Pacific humpback whale status and identify an important site for an endangered group of whales. These findings will contribute to effective local and international management, protection and conservation recommendations regarding humpback whales.

Numerical modelling approach for estimating listening space reduction in narwhal (Monodon monoceros) from vessels transiting through ice in Eclipse Sound, Nunavut, Canada

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This study investigates the potential for underwater noise from vessels, transiting through ice, to impact the listening space for narwhal in the Eastern Canadian Arctic, specifically in Eclipse Sound, Nunavut. A numerical modelling approach was used to examine the underwater sound footprint from commercial vessels transiting through ice along a newly established shipping route that overlaps with a summer calving ground for narwhal. Vessel noise partially overlaps in frequency with the lower range of narwhal hearing sensitivity and therefore has the potential to interfere with their ability to utilize sound to communicate, navigate, and forage. To investigate the extent to which vessel sounds could impact narwhal listening space, underwater sounds from vessels were modelled in 1/3-ocatve bands as a function of range and depth from the vessels. The modelled received sound levels were compared against median measured ambient sound levels and the assumed hearing threshold of narwhal (beluga audiogram used as a proxy for narwhal). The signal excess was examined to estimate the potential listening space reduction as a function of range from the vessels. The analysis was performed for individual 1/3-octave bands that correspond with the dominant frequencies for three narwhal vocalization bands: 1 kHz, 5 kHz and 31.5 kHz.

Bridging population genomics and conservation for harbour porpoises (Phocoena phocoena) in the North Atlantic and adjacent waters.

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The harbour porpoise (*Phocoena phocoena*) is a highly mobile cetacean found in waters across the Northern hemisphere. It inhabits basins that vary broadly in salinity, temperature, and food availability, which drives differentiation among populations. First ddRAD analysis showed a distinct genetic differentiation between the North Atlantic and the Baltic Sea population, with a further subdivision between the inner Baltic Proper and the Belt Sea. Additionally it could be shown that the population in the North Sea are genetically closer to Icelandic individuals than to the geographically adjacent Baltic Sea populations. We have extended the ddRAD sequencing data, adding samples from a broad distribution range (spanning form the Western Black Sea, the entire North Atlantic, and the Baltic Sea), and utilizing a newly assembled high quality reference genome, to further unravel subtle population structure. Using this new assembly as a reference, we have identified 51.055 genome-wide SNPs from 226 individuals. Initial results support the classification of a distinct Inner Baltic proper subpopulation, genetically differentiated from the population in the Belt Sea, and because of low numbers, critically endangered. These results support conservation measurements for the Inner Baltic Proper subpopulation, and provide the basis to develop a SNP panel to further management and monitoring of European populations, in particular the Baltic proper subpopulation. For such a panel, specific

SNPs are currently selected and tested for suitability for population diagnosis across the North Atlantic and adjacent waters. Together with the draft genome annotation (22,154 predicted genes), these genetic variants can also be linked to the proteins they encode, allowing for further investigation into local adaption and functional evolution in the different harbour porpoise populations. Our study underscores the value of whole genome resources in conservation genomics, and provides a crucial addition for the study of porpoise evolution and phylogeny.

The identification of critical habitats for cetaceans in the southern Adriatic Sea

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Critical habitat identification forms an essential stage in the implementation of Marine Protected Areas (MPAs). Whilst MPAs have been shown to be an effective conservation strategy, they cover just 6% of the Adriatic, with a single MPA, Karaburun Sazani, in the southern Adriatic. Apex predators can be used both as indicators of the health of critical habitats and flagship species of MPAs. The Adriatic Sea has been identified as a cetacean hotspot and yet is under a wide range of anthropogenic threats which have caused population declines up to 50% in bottlenose dolphins (*Tursiops truncatus*) and regional absences of common dolphins (*Delphinus delphus*). The current study runs the first dedicated cetacean research into critical habitat identification in the southern Adriatic. In Montenegro, 438 surveys have been conducted since September 2016 alongside 15 surveys in Albania since Novemeber 2018. A regular bottlenose dolphin presence and more sporadic striped dolphins (*Stenella coeruleoalba)* sightings have been confirmed in both countries, with a mixed group association in Albania as well as an unusual sighting of a group of common dolphins. Whilst the Albanian project remains in its preliminary stage, frequent delphinidae sightings have been observed at the Cape of Rodon. Montenegro revealed an encounter rate of 4 groups/100km, with similar seasonal sighting variations, and 90 identified dolphins to date. Montenegro is likely to hold migration corridor(s), important foraging habitats, nursing ground(s) with critical habitats delineated at the entrance of Boka Kotorska and the coastal waters of Katic, Bar, Utjeha and Ulcinj. The offshore waters of Platamuni may hold critical habitat(s) for striped dolphins, specifically between the 300 and 700m contours. The critical habitats delineated here show a striking overlap with current proposed MPAs in Montenegro and thus highlight the importance of cetacean research on MPA selection.

Fin whale and striped dolphin distribution patterns as response to environmental variability

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Highly mobile species interact with dynamic oceanographic processes that vary at time-scales from days to decades. Aim of this study is to outline the lessons learnt from a long-term monitoring study concerning occurrence, spatial and temporal distribution of cetacean species in an area of about 30,000 km^2 included within the Pelagos Sanctuary in the NW Mediterranean Sea. The data series derives from 29 years of dedicated shipboard summer surveys, conducted between May and October from 1990 to 2018. Indices of spatial patterns have been applied to the sighting data of the most frequent species (i.e. *Stenella coeruleoalba,* N: 3,953; *Balaenoptera physalus,* N: 958 sightings) and their variability was analyzed in

time. The analysis of the species distribution patterns revealed temporal and spatial significant variability (Kruskal-Wallis: $P<0.01$). Concurrently, a satellite area-averaged time series of 4 km chlorophyll-a was analysed. A Hierarchical Cluster Analysis allowed to identify five clusters of chlorophyll-a monthly patterns. The spatial distribution of the two species was found more clumped in years where the chlorophyll-a concentration was lower, and its spatial pattern more homogeneous, while it was dispersed in years where the chlorophyll-a concentration was higher, and its spatial pattern more heterogeneous (Kruskal-Wallis: $P<0.01$). These results suggest that the temporal variability of the species distribution may be affected by chlorophyll-a spatial patterns varying in time. A following simulation study based on 1,000 randomized sightings over an area of about 90,750 km^2 allowed to demonstrate how such patterns have also the potential to affect the estimates deriving from synoptic surveys aimed to assess abundance of species at the large scale. Spatial distribution patterns should be better investigated as function of environmental covariates, to improve the understanding of the species' ecology, and to inform models fed on data deriving from time-limited surveys, that are essential for conservation.

When is a peak in strandings relevant? 30 years of carcass collection provides basis for detecting exceptional events.

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Since the 1970s, the German Oceanographic Museum conducts a monitoring to collect marine mammal carcasses in Mecklenburg-Western Pomerania. From 1990 until today, a continuous development of the stranding network helps to investigate the three native marine mammal species in the German Baltic Sea. All harbour porpoises, harbour seals and grey seals are dissected to gain insight into different life history parameters and population health. A close cooperation between national parks, municipalities, authorities and a citizen science approach ensures that carcasses are collected and transported to freezers distributed along the coast. The analysis of stranding locations revealed annual patterns characterised by spatial and temporal species-separation. Harbour porpoises mostly wash up on western beaches, whereas grey seal carcasses were rather recorded at eastern beaches. Due to the long-term monitoring unusual events are easily detectable. For example, a grey seal mass stranding event in 2017 was detected due to fresh carcasses found in an unusual time of the year. The year 2018 was especially noticeable within the 30-year monitoring period, since maximum numbers for all species (69 porpoises, 16 harbour seals, 47 grey seals, 12 unidentified seals) were recorded. In grey seals, the recolonization on the German Baltic coast, with a steady increase of seal abundance, is a reasonable explanation for this strandings peak in this species. For harbour porpoises, on the contrary, passive acoustic monitoring does not reflect this development. Therefore, further investigations on the increase of harbour porpoise strandings at the German Baltic coast are necessary to find possible explanations to further conservation and management of this vulnerable small cetacean.

Using lagged re-identification rates to define associations from photographic data

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In studies of cetacean social structure, the challenge of finding suitable criteria to define associations when working with photo-identification data has been largely overlooked. Most studies define associations based on proximity in space and/or time, using criteria from previous studies on the same species. However, we now know that social dynamics of different populations can differ within the same species, which invalidates the use of generalized preconceptions of their social organization when collecting and analysing association data. Furthermore, association criteria based upon field observations are often subjective, which becomes problematic when data are collected over long timespans by different people or when protocols evolve over time (e.g., film and digital photography, which impose different constraints on the way data are collected).

We suggest a data-driven approach to define associations based upon photographic records by estimating the probability of re-identification of an individual over different lags (time or number of frames), and by determining when this probability becomes the same as that of a randomly chosen individual. We evaluated the effectiveness of this technique using both simulations and real

association data from populations with well described social structures, such as Northeast Pacific resident killer whales.

We found that this method removes the biases of subjectively defining associations in the field, allows for the combination of film and digital photograph data and for the homogenisation of data collected across sampling periods by different people. This is a promising approach to study populations with prominent fission-fusion dynamics and it is applicable to any dataset of sequential identifications when associated individuals can be assumed to be in close proximity to one another.

Where are we at: What is the state of play of harbour porpoise conservation in the North Sea region?

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Harbour porpoises (*Phocoena phocoena*) are an abundant and wide-ranging species in the North Sea but they face many threats from anthropogenic activities across international borders. Across the region their distribution and abundance has changed over the past few decades.

Different parts of international and national legislation are relevant to species conservation. A variety of different entities are working together through conventions, agreements, treaties and programs with the aim to contribute to harbour porpoise conservation and to manage threatening activities. These entities can have similar goals but their mandates have different coverages, approaches, cycles, structures and management actions. Multiple international directives, regulations and policies with different implementations at national level serve as legal tools to help this process. There is a need to optimize the coordination of these different entities and their activities to create more synergy with the ambition to improve conservation of this species in an adaptive way towards the future.

We conducted a three way conservation effort evaluation based on an extensive literature search and interviews with experts working in this field. First, we focused on the legislation basis for conservation (legal power and content), secondly, on mandate of the entities involved (spatial, temporal, jurisdiction and responsibilities), and lastly, on tools used to establish conservation (monitoring, assessment, juridical tools and impact).

Besides an overall North Sea region evaluation, the Netherlands species conservation approach was used as an example to evaluate efficiency of conservation in more depth and provide an example on the complexity and differences in implementation between countries of applied species conservation and management.

Our work shows that synergy is necessary in order to more efficiently and comprehensively implement all conservation efforts, solve gaps and increase effectiveness of harbour porpoise conservation. Suggestion for improved synergy and an action plan for the upcoming years are provided.

First assessment of the ecotoxicological status of Cuvier's beaked whale (Ziphius cavirostris) in the NW Mediterranean Sea

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Cuvier's beaked whale (Cbw) is one of the least known species in the world. The Mediterranean subpopulation is ranked as Vulnerable (VU) in the "IUCN Red List of Threatened Species", considering both the declining population trend both the low number of mature individuals estimated in the basin. While effects of underwater noise, known to be one of the main threats to the species, are being widely investigated, the ecotoxicological risk of the species is still unknown. The objective of this study is to investigate for the first time the ecotoxicological status of Cbw in the NW Mediterranean Sea (Pelagos Sanctuary). The levels of organochlorine compounds (PCBs), polybrominated diphenyl ethers (PBDEs), and related biomarkers responses (induction of cytochrome's P450 CYP1A1 and CYP2B isoforms) were investigated in 22 skin

biopsies from free-ranging organisms. This sample set represent about the 20% of estimated size of the resident population in the area which has been monitored during the last fifteen years. All the animals were sexed and categorized into three different age classes (juveniles, subadults, adults) by both the estimated size and coloration patterns. CYP1A1 and CYP2B protein activity show different trends among different age groups and between sex. The contaminants analysis highlight that the average abundance pattern for the target contaminants was PCBs>PBDEs and the concentration values are linked to age and sex, with males showing higher levels (∑PCBs 23.77 mg/kg l.w., ∑PBDEs 0.516 mg/kg l.w.) than females (∑PCBs 8.08 mg/kg l.w.,l ∑PBDEs 0.172 mg/kg l.w.). 80% of sampled cbw had PCB concentrations above the toxicity threshold for physiological effects in marine mammals, suggesting a potential effect on this mediterranean population fitness. This study represents an important step forward in our understanding of the effects of toxic compounds in combination with other known or suspected threats to this population of Cuvier's beaked whale.

The perils of relying on handling techniques to reduce bycatch in a partially observed fishery: A fatal flaw in the U.S. false killer whale take reduction plan.

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False killer whales (*Pseudorca crassidens*) are the most frequently-recorded bycaught cetacean in the Hawai'i-based deep-set longline fishery. High levels of false killer whale bycatch in this fishery led to the formation of a Take Reduction Team (TRT) in 2010 and subsequent implementation of a Take Reduction Plan (TRP) in 2013. The TRP mandates a combination of technical approaches (i.e., "weak" circle hooks and "strong" terminal gear, making the hook the weakest part of the gear) and handling techniques (putting tension on the gear). Combined, these approaches should reduce the proportion of hooked individuals that are seriously injured or suffer mortality (SI&M), a determination which is based, in part, on whether whales are able to free themselves from gear (e.g., hooks straighten or pull out). Observers on ~22% of trips provide information on observed SI&M rates that are extrapolated to the unobserved portion of the fleet to derive overall bycatch estimates. More than six years into the plan, rates of SI&M remain high. Even with observers on board, fishermen often (~29%) cut the line, rather than applying tension to straighten the hook. It is impossible to know whether an observer effect (e.g., fishermen cutting lines at higher rates when no observers are on board) occurs, but any such effect could result in bycatch estimates that are negatively-biased. At the time of abstract submission the TRT is deliberating the benefits of weaker hooks and stronger terminal gear to reduce SI&M rates. However, the reliance on handling techniques is a fatal flaw in a fishery that is only partially observed. Electronic monitoring (EM), specifically video monitoring, in the entire fishery could overcome this shortfall. The presence of EM would increase compliance with handling techniques and allow for a full assessment of compliance, to help determine whether additional changes to the TRP are needed.

Species identification of cetaceans by environmental (e)DNA metabarcoding – a new tool for surveys of the high seas.

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We are developing methods for detection and identification of cetacean species using environmental (e)DNA collected from seawater at the surface and at depths, in open-ocean conditions. Referred to as 'eDNA metabarcoding', the potential to confirm species identity and population identity, from environmental sampling can complement the interpretation of acoustic and visual surveys now used to monitor cetaceans on

the high seas. Here we have used droplet digital (dd)PCR to detect and quantify eDNA, and next-generation sequencing (MiSeq) for species identification. Opportunistic, focal sampling in the vicinity of whales and dolphins has now been completed in open-ocean conditions in the western North Atlantic, the South California Bight, Hawaii, the Bering Sea, New Zealand, and the Mediterranean Sea, from both small and large vessels. To date, eDNA metabarcoding of focal samples has confirmed identification of 7 species of odontocetes including two beaked whales: Baird's beaked whales (*Berardius bairdii*) and True's beaked whales (*Mesoplodon mirus*). For Baird's beaked whales, we found differing presence/absence and frequencies of two haplotypes, indicating the potential for population level differences. For the True's beaked whales, we found two new haplotypes not previously reported in the literature. 'At depth' sampling of eDNA by CTD casts (60-1,000m) at the Cross Seamount, west of Hawaii, identified false killer whales (*Pseudorca crassidens*) in the absence of any coincident visual or acoustic detection. The haplotype detected at the Cross Seamount did not match those reported for the island-associated populations of Hawaii but was, instead, most similar to those of pelagic populations in the central and eastern North Pacific. Our results confirm the power of eDNA metabarcoding to improve success with identification of elusive species and the potential for use in systematic surveys of species occupancy in high-seas habitat, such as Important Marine Mammal Areas (*IMMA*s) in remote locations of the world's oceans.

Development of a SNP panel for genotyping polar bears from non-invasive samples.

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Obtaining genetic samples from polar bears (*Ursus maritimus*) typically involves live-capturing individuals, a difficult and expensive process. Hair and scat are potential non-invasive source of DNA; however opportunistically collected samples may be exposed to UV and freeze-thaw cycles over an unknown extent of time, resulting in DNA degradation. In this study we investigate the quality and quantity of DNA recovered from non-invasive sampling methods and develop an inexpensive protocol for genotyping potentially low-quality and low-quantity non-invasive samples of polar bear hair with a panel of single nucleotide polymorphisms (SNPs). SNPs are preferable over microsatellites (traditionally used for individual genetic identification) for degraded samples as they are more robust against DNA fragmentation, providing higher genotyping success and confidence. We compared opportunistically collected and three sources of hair : pulled directly from live-captured individuals (positive control), collected from hair snares; and collected opportunistically from "daybeds" to determine whether these methods are useful for genetic identification. Hairs were processed individually with a forensic approach to prevent the possibility of cross-contaminating with hairs from different individuals. Hair samples were first DAPI stained and inspected under a microscope to visually estimate the concentration and distribution of DNA throughout the hair. We then optimized extraction and sequencing library preparation protocols to maximize DNA recovery from degraded samples. We used high coverage whole genomes of six Alaskan polar bears to develop a panel of SNPs that is sufficiently informative to genotype individuals from low-quality samples and genotyped the hair extracts at these loci. The results of this study will inform future sampling efforts and provide a methodology for genotyping individuals from non-invasive for applications such as genetic mark recapture, abundance estimates, and population assignment.

Population-level impacts of natural and anthropogenic causes of death in Main Hawaiian Islands monk seals

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Prioritizing measures to conserve endangered species should be informed in part by the degree to which individual threats are impeding population recovery. We therefore quantified the impact of various causes-of-death (CODs) on the intrinsic growth rate, λ, of Hawaiian monk seals in the main

Hawaiian Islands (MHI). Seals are exposed to natural CODs, including reproductive complications, natural trauma, and malnutrition. Anthropogenic CODs include fisheries interactions and intentional killing by people. Disease is another source of mortality, and may ultimately be attributable to either natural or anthropogenic factors. We reviewed all known deaths in the MHI and used gross necropsy results, histopathology, and other evidence to assign probabilities of 11 distinct CODs to each case. Next, survival estimation linked to lifetable analysis was repeated 1000 times using Monte Carlo sampling of the COD probabilities to assign causes to each death occurring from 2004 to 2018 (including 81 known deaths and 102 others inferred from sighting histories). Inferred deaths were randomly attributed to causes according to the age- and sex-specific COD probabilities derived from known cases. We estimated influence on λ (and its associated uncertainty) by using right censoring to selectively remove each COD's effect on survival rates. The baseline scenario, with all CODs influencing survival, yielded mean λ=1.044. When the effect of an individual COD was selectively removed, the magnitude of the resulting λ relative to this baseline provided a measure of that COD's drag on population growth. The CODs with the greatest population impact were intentional killing, drowning in nets, and protozoal disease; removing any one of these was estimated to raise mean λ to at least 1.061. In aggregate, removing anthropogenic CODs had a larger mean effect (λ=1.093) than either natural (λ =1.059) or disease CODs (λ=1.068). This analysis provides a common currency for assessing the relative potential benefits of mitigating individual threats, thereby informing prioritization of conservation measures.

Prolonged, sub-surface, visual observations of free-living killer whale (Orcinus orca) feeding behaviour in northern Norway.

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Cetacean behaviour is typically inferred from visual observations or from analysis of data from instruments attached to the animals. Proxies for behaviour are employed when using instrumental data (e.g location, depth, speed, acceleration and sounds produced). Direct visual observation is typically limited to above or just below surface displays while indirect visual observation even at depth through photos or videos is usually limited in view field. We gathered direct sub-surface observations up to a depth of 15m of orca feeding and social behaviour that can be integrated with other data for a more profound understanding of the ecology of this species. A single person snorkelling in the proximity of the animals gathered the data over six years using a minimal-impact protocol that aimed at maximising the chance of observing naturally acting animals. Particular behaviours have been recorded on video. Our observations revealed that in our area, although feeding mostly on herring, occasionally orcas take seals. Herring capture happens frequently for up to two hours in a carousel situation often with reduced acoustic behaviour, at different depths often herding the bait ball. Tail slapping with actual fish contact follows, occasionally simultaneous by up to 3 individuals. Sharing of the stunned fish is the norm. The bait-ball is incompletely consumed and usually no stunned fish are left. Large whales irrupt in the carousel and depredate the ball after which the carousel is resumed, but aggressive reactions by the orcas have occasionally been witnessed. Shallow water feeding by adult males alone or in small groups involves isolating individual fish for direct capture. Predation on harbor seals after feeding on fish has also been observed testifying that these orcas are not specialists. We believe that our observations can provide essential information for the interpretation of tag data with particular regard to accelerometry.

A review of recent cetacean stranding records in the United Arab Emirates (UAE) suggests the need of cooperative systematic data collection to better address main threats in the region

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Strandings provide an insight on the presence of species in a region and access to morphological, life history traits and ecological data otherwise difficult to obtain. Stranding analysis can also identify the main cause of death and in turns the main threats that affect a population in a region, such as by-catch, boat strikes, overfishing or pollution. Ultimately this information can play an important role in supporting the formulation of effective conservation measures.

In the UAE waters (Arabian/Persian Gulf and northernmost Arabian Sea) recent information about cetaceans are scarce. Most published stranding records are from the 20th century, but not many are available from the last two decades. The Gulf accounts for the presence of 13 cetacean

species but little is known about their population status. For some them, stranding data is the only documentation of their occurrence.

In this study we collated all stranding records available in the UAE online newspaper and those received by the public and local authorities through the UAE Dolphin Project initiative. Each record was reviewed for the location, date of stranding, the authenticity of the associated photographic material verified and utilised to assess the species. All strandings from the region published in scientific papers were tabulated and compared it with the unpublished records found.

A total of 46 strandings (12 Mysticetes, 29 Odontocetes) were found occurring between 2006 and 2018 in UAE waters and neighboring countries (Saudi Arabia and Kuwait). Among the Mysticetes seven Bryde's whales, one blue whale and one humpback whale were confirmed. Among the Odontocetes four toothed whales (three sperm whale and one dwarf sperm whale), 22 dolphins (16 Indo Pacific bottlenose dolphins, three Indian Ocean humpback dolphins, one spinner dolphin) and three finless porpoises. This highlights the importance of **systematic data collection and the implementation of organised stranding networks.**

Space vs Sea: A novel method for estimating marine mammal density.

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Implementing informative, regular and representative surveys to assess whale spatial usage remains a logistical and economic challenge. Consequently, they are broadly omitted from Southern Ocean marine protected area designations and ecosystem-based fisheries quota assessments. Here we compare at-sea measurements of whale density in the Western Antarctic Peninsula with density estimates from satellite images. We demonstrate that Very-High-Resolution WorldView-3 imagery can provide useful data on whale occurrence and density. Densities, when unadjusted for surface availability are shown to be underestimated by a factor of 9 (CV = 0.24) in relation to concurrent ship based survey methods, but once adjusted (0.049 to 0.089 whales per km^2), are within an order of magnitude of those derived by traditional line-transect estimates (0.369 whales per km^2). Satellite mediated surveys, whilst in their infancy, represent an exciting development for high resolution image-based cetacean observation at sea, particularly in remote and inaccessible regions, presenting opportunities for future research.

Diving in the deep? Sei whale's dive behavior in the western South Atlantic.

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Sei whales (Balaenoptera borealis) are widely distributed in all major oceans, but their diving behavior is relatively poorly understood, especially in their wintering grounds. In this study, six whales were instrumented with archival satellite tags (n=6) and a digital acoustic transmitter (DTAG) off the southeast coast of Brazil as part of the Cetacean Monitoring Project (PMC-BS/PETROBRAS). The transmission of the satellite tags lasted from three to 59 days and recorded 4773 dives. Dive depths recorded by these tags ranged between 5 and 577m (mean = 19.11, SD=34.51m). Dives between 5 and 15m (83%) and lasting from 5 to 10min (30%) were the most frequent. Surface interval ranged from 5s to 16min and 15s (mean = 13min, 27s, SD=3min, 12s). The individual tagged with DTAG was monitored for 5hs resulting in a total of 584 dives, of which 85% (n=498) were performed less than 1m from the surface and 15% (n=86) were below 2m of depth. The dives performed below 2m had an average duration of 2.8min, SD= 2.9min and reached an average depth of 5.5m, SD=3.5m. The maximum dive depth and duration recorded by the DTAG were 29m and 11.2min, respectively. Data from the DTAG motion sensors revealed a characteristic feeding behavior with lunge feeding near the surface. All the whales remained over the continental slope throughout the transmission period. Results suggest that while sei

whales typically dive shallow, dives can exceed 500m. The feeding behavior recorded by the DTAG may indicate that the occurrence of the sei whale in the Santos Basin is also related to feeding, even during the breeding season. Most dives recorded were within a depth range known to make cetaceans susceptible to collisions with vessels (<20m), emphasizing the importance of adopting measures to minimize ship strikes in this region.

An ounce of prevention is worth a pound of cure: Vaccination and other conservation interventions in Hawaiian monk seals

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Morbilliviruses have caused thousands to tens of thousands of deaths in several phocid species around the world. Exposure to morbilliviruses has not been documented in endangered Hawaiian monk seals, despite several decades of health monitoring. This naïveté in a small population (1,400 individuals) with poor genetic diversity indicates that the species is not likely capable of sustaining an outbreak. To protect Hawaiian monk seals, a vaccine targeting canine distemper virus in ferrets was evaluated and has been in use to proactively vaccinate wild seals since 2016 at a level sufficient to prevent an outbreak of morbillivirus from devastating the species.

The conservation crisis of cat scat: We need greater consistency in the evaluation of Toxoplasma gondii infections in marine mammals.

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The impacts of *Toxoplasma gondii* infections in marine mammals are reaching a critical conservation threshold, especially in endangered populations like Hawaiian monk seals (*Neomonachus schauinslandii*) where toxoplasmosis is the leading disease-related cause of death. Although infections from this parasite are geographically and taxonomically widespread, their impacts on species decline can be insidious. This stalls our collective ability to relate infections to measurable conservation impacts and take subsequent action. Best studied are sentinels such as the Southern sea otter (*Enhydra lutris*), which demonstrate a clear threat from land-to-sea flow of *T. gondii* oocysts from felids, the only known definitive hosts, to marine ecosystems. For many marine mammals, sample sizes are small, disease severity and detectability vary considerably, and findings are difficult to reconcile with dynamics in individual susceptibility. Our ability to detect and characterize transmission in diverse marine food webs is limited, sample availability and quality from marine mammals and the environment is variable, and validated diagnostic tests are scarce. These aspects of *T. gondii* research make it challenging to characterize and communicate a terrestrial-sourced marine mammal conservation threat in a unified way that allows managers and stakeholders to embrace much needed, yet often polarizing solutions. Despite information gaps, current knowledge is sufficient to inform plans of action in many cases. In the future, the paired use of histopathology and sensitive/specific molecular diagnostics will improve how we define the impacts of infection across taxa and resolve the influence of other stressors on immunity. More broadly, *T. gondii* in marine mammals serves as a red flag for the global health problem of environmental pathogen pollution, especially in coastal ecosystems. Our interdisciplinary scientific community must work across regional and taxonomic boundaries to improve consistency in research and messaging on this important health threat.

Stenella longirostris and Stenella attenuata (Odontoceti: Delphinidae): Whistle comparisons in the Western South Atlantic Ocean.

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Dolphins produce a variety of whistles, which together make up the repertoire of such tonal sounds of a particular species. Despite being phylogenetically related, *Stenella longirostris* (*Sl*) and *Stenella attenuata* (*Sa*) are expected to have different acoustic repertoires, since whistles are related to behavioral, individual, social and species-specific factors. In the present study, we describe and compare the acoustic parameters of whistles for both species recorded in Northeast Brazil. The whistles were divided into contour categories and its parameters were extracted for each type of contour using Raven Pro 1.5 (Hann window of 1024 samples, DFT of 2048 samples and 80% of overlap). The Mann-Whitney test ($\alpha<0.05$) was applied through R to compare the parameters of each type of contour between the two species. The whistles of *Sl* (n=82) and *Sa* (n=77) presented the following contour types respectively: ascending [n=53 (66%); n=56 (74%)], descending [n=10 (12%); n=4 (5%)], ascending descending [n=5 (6%); n=10 (13%)], descending ascending [n=7 (9%); n=3 (4%)], constant [just for *Sl* n=6 (7%)] and multiple [just for *Sa* n=3 (4%)]. For all whistles analyzed, regardless of the contour, only the center frequency parameter did not present a significant difference. When considering contours, ascending, descending and descending ascending whistles presented significant differences between the two species for at least seven of the eight parameters analyzed. The ascending differed in all eight parameters (beginning frequency, ending frequency, high frequency, peak frequency, center frequency, delta frequency and duration), whereas for descending and descending ascending only the low frequency did not differ significantly. The results indicate that ascending, descending and descending ascending whistles have the potential to carry species-specific information, while the ascending descending whistles, apparently, contributes less to the discrimination of these two species.

Gross and microscopic anatomy of the olfactory system of a grey seal, Halichoerus grypus

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There is very little research on olfactory sensory processing by marine mammals and much of this has focused on species that do not appear to have the ability to smell, such as the toothed whales. However, behavioral research and anecdotal evidence indicates that seals have a well-developed sense of smell, similar to canines, their terrestrial counterparts. These animals spend a significant amount of time living in the ocean but haul out onto land for major events such as mating and would likely use their sense of smell predominantly during these terrestrial periods. To date, little to no research has been completed on the anatomy of the seal's olfactory system, however, the presence of the vomeronasal organ (VNO) has long been assumed. This organ is known to play an important role in pheromone detection and would explain the reproductive behavior of seals. We have examined the head of a female grey seal, *Halichoerus grypus,* which died naturally. The tissue was fixed in formalin and dissected using an autopsy saw to expose the nasal cavity and hard palate. Grossly, the seal does have a VNO, well developed ethmoturbinates, and a large olfactory nerve (CN1). Histologically we have identified respiratory and olfactory epithelium. The histology of the VNO is still being examined. Overall the grey seal has very intricate ethmoturbinates and a potential VNO which is comparable to that of the olfactory system of canines. This anatomy would explain seals' behavior during reproductive periods and represents the first examination of the olfactory system of a pinniped.

Population genomic structure of common dolphins (Delphinus delphis) in Australia and New Zealand

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Clarifying population structure and connectivity in widely distributed marine taxa can be challenging due to vast spatial scales and poor knowledge about environmental barriers to dispersal. Genomic datasets provide great power for detecting population structure and environmental adaptation. Common dolphins (*Delphinus delphis*) are highly mobile and gregarious, exhibiting potential for large-scale connectivity. Their populations, however, may associate with meso-scale oceanographic features, and their movements perhaps dictated by the distribution of their prey. Association with schooling fish targeted by major fisheries consequently increase their vulnerability to fisheries by-catch. We analysed 480 samples from biopsied, bycaught and stranded common dolphins collected from across 20 locations that cover majority of the species range in Australia and New Zealand. Our aims were to elucidate their population genomic structure, fine and large-scale connectivity and patterns of adaptive divergence across environmentally heterogeneous coastal and oceanic regions. Using ddRAD-seq and over 15,000 high quality neutral SNPs, we identified three metapopulations across the region linked by low contemporary connectivity: a) eastern Australia, b) southern Australia, and c) Tasmania/New Zealand. We also detected further subdivision and asymmetric migration rates within these metapopulations. We identified a major oceanographic barrier to common dolphin movements and gene flow between the Indian and Pacific Oceans. However, contrastingly high connectivity was also inferred across the Tasman Sea. Genotype-environment association analyses detected adaptive divergence among metapopulations, with preliminary analyses suggesting at least 50 putatively adaptive markers. These findings improve current understanding about the nature and extent of dispersal barriers, as well as migratory corridors, for pelagic marine predators. They also clarify the number of common dolphin populations in Australia and New Zealand for the management of fisheries interactions.

Temporal acoustic occurrence of deep-diving cetaceans off western Ireland in areas under seismic license.

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Sperm whales (*Physeter macrocephalus*) and long-finned pilot whales (*Globicephala melas*) are the two most abundant deep-diving cetaceans off western Ireland. The aim of the present study is to investigate their temporal variability in occurrence off western Ireland to address a knowledge gap in these waters which hold significant potential for the exploration hydrocarbon resources. Fixed bottom-mounted autonomous acoustic recorders were deployed across 13 stations along the shelf-edge and canyon habitats as part of a Woodside Petroleum LTD study and ObSERVE-Acoustic. Three SM2M were deployed from May to September 2014 (123 days of recordings) on northern, south-western and southern slopes and canyons of the Porcupine Bank, four AMARs from May to December 2015 on Ireland's northern slope (214 days) and six AMARs from March to November 2016 on the western and southern slopes and to the east and north of the Porcupine Bank (230 days). Seasonal, lunar and diel effects will be explored using Generalised Estimating Equations (GEE-GAMs) for each mooring. Preliminary analyses of the data collected by Woodside revealed that sperm whales and pilot whales were detected across 47% and 41% of the recording days in 2014 respectively, and 78% and 28% in 2016. In 2014, 69% of the sperm whale clicks (9,295) and 55% of the pilot whale whistles detected (1,347) occurred to the southwest of the Porcupine Bank. In 2016, 80% of the pilot whale whistles were recorded by the northern mooring (984), while sperm whale clicks were more evenly spread out among the two locations. Based on these joint datasets, analysis will be performed on the largest offshore acoustic dataset from such devices collected across Europe to date, providing robust results contributing towards mitigation strategies by minimising the spatial and temporal overlap between these species and human activities.

Cloudy with a chance of whales: Forecasting blue whale occurrence based on tiered, bottom-up models to mitigate industrial impacts.

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A blue whale foraging ground was recently discovered in the South Taranaki Bight region of New Zealand, where anthropogenic pressure exists

from oil and gas extraction, vessel traffic, and proposed seabed mining. A knowledge gap on blue whale habitat use patterns impedes effective management of potential threats. While species distribution models (SDMs) of cetaceans often use remotely-sensed data due to the accessibility of satellite imagery, this approach makes assumptions about underlying relationships between oceanography, prey, and predators. We investigated these assumptions and built a series of models linking: a) blue whales and prey, b) prey and *in situ* oceanography, c) blue whales and *in situ* oceanography, d) *in situ* oceanography and satellite imagery, and e) blue whales and satellite imagery. We implemented the SDMs using three years of vessel-based survey data, including 151 blue whale observations over 4,752km of effort, prey metrics extracted from 156 hours of hydroacoustic backscatter data, and oceanographic features such as temperature, thermocline strength, and fluorescence calculated from 196 CTD casts. Significant predictors of blue whale presence from the blue whales and prey model included number of krill aggregations, aggregation density, depth, and thickness (deviance explained = 45%). Blue whale presence was higher where the thermocline was weaker, and thermocline strength was negatively related to number of krill aggregations and aggregation density. The blue whales and satellite imagery model revealed that 36% of the pattern in blue whale presence could be described using sea surface temperature alone, and identified an apparent preferred range of 17-18°C. Finally, predictive models of blue whale presence using satellite imagery were positively validated with independent sightings data, demonstrating their utility for forecasting blue whale distribution using remotely-sensed environmental features. By linking functional ecological relationships with readily accessible data sources, we aim to provide managers with a practical tool for real-time conservation.

Abundance estimation for Mesoplodon beaked whale species using drifting acoustic recorders.

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Using typical visual survey methods, abundance estimation for beaked whales in the genus *Mesoplodon* is especially challenging. Because surface times are brief and species-specific sighting characteristics are largely limited to males, only 23% of 461 *Mesoplodon* sightings on SWFSC surveys are identified to species. In contrast, beaked whale echolocation pulses are easier to identify, and although not all pulse types have been mapped to species yet, steady progress is being made. We use duty-cycled passive acoustic recordings from drifting recorders to estimate density and abundance for three *Mesoplodon* pulse types along the U.S. West Coast (thought to be *M. stejnegeri*, *M. carlhubbsi*, and *M. perrini*). Point-transect distance-sampling methods are used with a "snapshot" approach. Detection probabilities as a function of range are estimated from observed distributions of vertical detection angles and from distributions of foraging depths. Tagging and acoustic localization data for *M. densirostris*, *M. europaeus*, and *M. mirus* show mean echolocation or foraging depths of ~800-900 m. With these as informed priors on the echolocation depths of West Coast species, we use a Bayesian simulated likelihood approach to estimate detection probabilities as a function of slant range, translate that to probabilities of detection as a function of horizontal range and apply point-transect sampling theory to estimate the density of echolocating whales. These estimates are extrapolated to account for non-echolocating whales using diving and foraging behavior from other *Mesoplodon* tagging studies (largely *M. densirostris*). Pooled abundance estimates for all species are roughly comparable with estimates from visual sighting surveys, but, for the first time, this method allows the potential of species-specific abundance estimates and precise trend monitoring.

Eavesdropping on foraging and social sounds of conspecifics influence the horizontal movement of Risso's dolphins

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Risso's dolphin (*Grampus griseus*) is a social odontocete species living in long-term stable groups composed of males or females and their offspring. Its vocal repertoire includes various

social and foraging sounds. We hypothesized that Risso's dolphins can gather information by eavesdropping on sounds produced by their congeners, enabling them to adjust their behaviour according to the perceived context. To investigate this hypothesis, we conducted sound playback experiments on free-ranging Risso's dolphins in the North Atlantic Ocean (Azores archipelago). We exposed animals to conspecific foraging sounds potentially indicating the presence of food patch (Fo, N=6 groups), male social sounds simulating a potential risk of agonistic interaction with territorial males (SM, N=4 groups), and female-calf social sounds likely representing no risk of threatening interaction (SF, N=7 groups). Individual and group track was recorded using visual or airborne (camera drone) focal follow observations. Horizontal movement responses during sound playbacks were quantified using the horizontal track of the animal. Overall, Risso's dolphins were horizontally attracted towards both Fo and SF stimuli whereas they avoided SM stimulus. When attracted, animals probably aimed at investigating the sound source and gathering additional information. The detection of conspecific foraging sounds by individual eavesdroppers may indicate the presence of a food patch being predated upon by conspecifics thus providing a "diner bell" signal. To confirm this hypothesis, further investigation on the behavioral response of dolphins during their approach is needed. In a social setting, male sounds could be perceived as a potentially risky interaction that individuals may avoid. Our results demonstrate that Risso's dolphins can discriminate between conspecific sound stimuli emitted in different contexts, and show evidence that eavesdropping on conspecifics sounds clearly influence their behavior.

Mitochondrial phylogeography of southern elephant seals (Mirounga leonina) around Antarctic waters with emphasis on the population structure of the colony at Isla 25 de Mayo (King George Island) South Shetland Islands, Antarctic Peninsula

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The southern elephant seal (SES) (*Mirounga leonina*) has a circumpolar distribution, breeding mainly on sub-Antarctic islands, and making long trips up to thousands of kilometers between breeding colonies, molting locations and foraging areas. Although individuals show fidelity to a set of established breeding colonies, their migratory habits to forage at sea at large distances from their colonies, may allow long-range gene flow. To assess mitochondrial phylogeography of SES around Antarctic waters, with emphasis on population structure of the colony at Isla 25 de Mayo (62º15'S, 58º39'W), skin samples from free-ranging sub-adult male and adult females SES (n=60) were collected with a remote biopsy dart during 2015-2016 austral summer. The mitochondrial DNA Control Region (mtDNA-CR, 325bp) and 10 microsatellite loci were analyzed. The mtDNA-CR results indicate that SES from Isla 25 de Mayo are closely related with individuals from Elephant Island, Livingston Island, and Islas Malvinas (Falkland Islands), but maintain restricted genetic flow with individuals from Victoria Land Coast in the Ross Sea and Macquarie Island. Haplotype diversity was high and similar to the values found at other locations around Antarctica. Microsatellite analyses confirmed data indicated high genetic diversity (allele number ranging between 2 and 12; observed heterozygocity ranging between 0.422 and 0.883). Parentage analyses ran on ML-relate software identified 2% of individuals in the sample as mother-offspring, 16% as full/half siblings and 82% as unrelated individuals. These results agree with previous findings of long-distance genetic dispersal mediated mainly by SES males. Migration, accompanied by high genetic diversity may facilitate dispersal and discovery of emergent habitats, particularly in the potential loss of habitat due to climate change.

Radiographic assessment of pectoral fin bone maturation in bottlenose dolphins (Tursiops truncatus), as a novel technique to accurately estimate chronological age.

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Accurate age estimation in wildlife conservation is an important diagnostic tool in the interpretation of biological data, necropsy examination, reproductive status and population demographics. The most frequently utilized methods to age bottlenose dolphins (*Tursiops truncatus*) include tooth extraction (counting dental growth layer groups) and dental radiography. These methods are inaccurate in dolphins > 13 years old, due to overlapping of the growth layer groups in dolphins, or worn teeth. Establishing a non-invasive method of accurately ageing bottlenose dolphins across the entire age range is important to long term conservation efforts to understand health status, lifespan, reproduction and survivability.

A database of 120 radiographs from 93 dolphins, in managed care, of known chronological age, was utilized to establish the stages of skeletal maturation over time. A numerical score from -1 to 8 was assigned to 16 anatomic locations on the pectoral radiograph, to create a formula to estimate age. The most informative areas to evaluate morphologically were the metaphyseal regions of the radius and ulna, and the proximal and distal epiphysis of metacarpals II and III. Third order polynomial regression calculated separate age predictor formulas for male and female dolphins, with females reaching bone maturity earlier than males. Completion of epiphyseal closure of the long bones correlated with average sexual maturity. Ages could be estimated to within 3 months in animals < 5 years old, within 2 years between 5 and 30 years, and within 5 years in animals > 30 years old. This diagnostic tool could also be applied to diagnose atypical ossification patterns consistent with nutritional disorders or growth abnormalities, identifying subclinical health issues. Knowledge of the lifespan of the cetacean and the onset of sexual maturity may allow this model to be applied to other cetacean species, to facilitate age estimation via pectoral radiography in future research.

Diversity and abundance of marine mammal strandings along the SE/S Brazilian coast (2016-2018).

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Since August 2015, marine mammals stranded between 25°05'S and 25°55'S have been recorded by the Santos Basin Beach Monitoring Project (Projeto de Monitoramento de Praias da Bacia de Santos - PMP-BS). The PMP-BS is one of the monitoring programs required by Brazil's federal environmental agency, IBAMA, for the environmental licensing process of the oil production and transport by Petrobras at the Santos Basin pre-salt province(25°05'S 42°35'W a 25°55'S 43°34'W), between 2100m and 2300m isobaths. As part of its goals, the diversity and abundance of marine mammals have been evaluated. A total of 1032.7Km of beaches on coastal areas and islands is monitored, 79.7% of it being regularly monitored, and the remaining 20.3% only by responding calls from the local population. A total of 3532 marine mammals (495 pinnipeds and 3037 cetaceans) were recorded, of which 92.4% were dead. Thirty species were recorded, six of them from the order Carnivora and 24 from the infraorder Cetacea. Among the carnivores, the species with the greatest abundance was *Arctocephalus tropicalis* with 39.5% of the records. For cetaceans, *Pontoporia blainvillei* comprised 61.7% of the records, followed by *Sotalia guianensis* with 24.30%. While some species were relatively abundant, the following had only single records during the three years: *A. gazella, Balaenoptera physalus, Feresa attenuata, Kogia sima, Lagenodelphis hosei, Orcinus orca, Peponocephala electra, Physeter macrocephalus, Stenella attenuata* and *S. coeruleoalba*. Considering each year separately, 2016 presented the greatest species richness, with 23 species, while 2018 had the highest number of animals, with a total of 1338 records (2016 = 1223, 2017 = 971). The rarefaction curves were also calculated, indicating that the species richness has not yet been reached in this area. The monitoring program is ongoing and future data will probably allow identifying finer biogeographic patterns.

Investigating the energetic cost of human disturbance on the southern sea otter (Enhydra

lutris nereis).

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With increased human populations and tourism in coastal areas, there is increased potential for disturbance of marine wildlife. Impacts of disturbance are not well understood for many coastal species, such as the southern sea otter (*Enhydra lutris nereis*). Due to high metabolic rates, sea otters are at particular risk of increased energetic costs due to human disturbance. To investigate effects of disturbance, behavioral scans were conducted over three years to record sea otter activity in response to potential disturbance stimuli at three locations in California: Monterey, Moss Landing, Morro Bay. We developed a hidden Markov model to examine how activity varies as a function of location, time of day, group size, pup to adult ratio, habitat (kelp vs. open water), and occurrence of and proximity to potential disturbance stimuli. We combined our results with published estimates of activity-specific metabolic rates, translating changes in activity state into corresponding energetic costs. Our results indicate that the effects of disturbance stimuli on sea otter behavior are location specific, and vary non-linearly with distance from disturbance stimuli. Our model quantifies the distance-disturbance relationship, and calculates the distance at which the likelihood of disturbance is low: averaged across locations, there is <10% potential disturbance when stimuli are >54 meters away. We also estimate energetic costs(kJ) associated with various disturbance scenarios: for example, daily energy expenditure is expected to increase by 212.53kJ± 15.75, 154.64kJ ± 13.84and 62.54kJ ± 5, for Monterey, Moss Landing and Morro Bay, respectively, with six small-craft approaches of <20m for a 27.7kg male otter in kelp with 10 otters and a pup ratio of 0.25. Our analyses represent a novel approach for estimating behavioral responses and energetic costs of disturbance, thereby furthering our understanding of how human activities impact sea otters and providing a sound scientific basis for management.

The answer for resident killer whales: Mating is by female choice. What was the question?

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Species that mate in three-dimensional environments frequently exhibit reverse sexual size dimorphism, where male agility is advantageous. In killer whales, however, males are larger than females, suggesting sexual selection mediated through female mate choice. Here, we present relevant observations from 126 combined field seasons of boat- and drone-based killer whale research in the Northeast Pacific. First, we found male-male sexual interactions to be common. These putative practice mating sessions did not appear to include any practice of sexual coercion. Second,we found heterosexual interactions to be less common and less protracted, as expected in social species where females have opportunities to evaluate males prior to making mating choices. Third, we found that heterosexual interactions usually involved a single male and we found no evidence of male coalitions that could constrain females during mating. Evolutionary theory predicts that females should be more selective than males in choosing mates. In light of this and the above observations, we hypothesize that a robust female mate choice system is responsible for two strikingly-unusual characteristics of resident killer whales. First, we propose that their unique social system – characterized by stable matrilines in which male and female siblings remain in association throughout their lives – exists because mating control allows females to realize inclusive fitness benefits of living with kin while avoiding fitness costs of incestuous matings. Second, we propose that the extreme subdivision of killer whales into small, closed populations is a consequence of females choosing mates from other matrilines, ultimately creating discrete kinship networks that diverge socially and genetically from other kinship networks. Finally, we make the case that the effectiveness of female mate choice in preventing inbreeding may be compromised by skewed sex ratios and/or limited numbers of adult males, as evidenced by previous studies showing substantial differences in consanguineous mating rates between two resident killer whale populations.

Intra-skeletal variability of stable isotope ratios of C and N in pinnipeds and cetaceans.

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Stable isotope ratios of different bones (atlas vertebra, humerus and basioccipital) from different skeleton regions of two phylogenetically unrelated groups of marine mammals, Otariidae and Delphinidae, were analysed before (bluk) and after delipidation and demineralization (dml). Results revealed that combined delipidation and demineralization resulted in a significant increase in the $\delta^{13}C$ and $\delta^{15}N$ mean values of the basioccipital in both species, no effect on the $\delta^{13}C$ and $\delta^{15}N$ mean values of the atlas of any species and species dependent effects on the $\delta^{13}C$ and $\delta^{15}N$ mean values of the humerus. Furthermore, results confirm that the $\delta^{15}N_{bulk}$ values of different skeletal elements from the skull, the axial skeleton and the proximal part of the appendicular skeleton of cetaceans and pinnipeds are interchangeable. However, caution is needed when dealing with bones made up only by cortical bone, such as basioccipital, because the $\delta^{13}C_{dml}$ value and the collagen contents could differ significantly from those of other bones. Bones from the distal part of the appendicular skeleton may also differ in stable isotope ratios, as suggested by previous research. Finally, combined treatments have a strong influence in both $\delta^{13}C$ and $\delta^{15}N$ and hence values from bulk and pretreated samples should not be compared directly.

Dolphins of Montenegro - walk the walk, talk the talk

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The South Adriatic is an underrepresented territory regarding scientific research and conservation. Montenegro Dolphin Research was initiated in order to actively increase public awareness and conservation efforts regarding the cetacean population of Montenegro. Along with 400 days of scientific research, we've created several awareness campaigns to educate and inform the citizens of Montenegro. Since September 2016, we built up a website and initiated a social media account with 12.7k followers, gave five school and pre-school presentations, organized 11 beach cleanings, opened an 'Awareness Stand', generated an 'Adopt a dolphin' campaign and gave an interview for the national newspaper 'Vjesti', collaborated with the local and international NGO's, invited residents to our 'Community day', constructed a lifesize dolphin from recycled materials and displayed it on the beach, organized four arts and crafts workshops with everyday single-use plastic, shared daily posts and arranged meetings with the municipality. Following the pre-seismic surveys that took place in Montenegro in December 2018, we published a seismic report and created a stranding network in order to track possible stranding cases.

Our intention is to support citizen science and motivate the public to contribute to conservation efforts and let them be conscious of the effects of threats, such as plastic pollution, ghost nets, seismic surveys, and dynamite fishing. This year, we will create an art exhibition that displays the hardships of cetaceans' everyday lives and the obstacles that they encounter. The exhibition will feature as an interactive performance where the observers will ''walk the walk'' whilst facing and experiencing the hazardous and inevitable consequences of the anthropogenic effects of our time through a hall of pictures.

Montenegro Dolphin Research is creating new conservation ideas continuously to raise public awareness by broadcasting environmental issues regarding our ecosystem and nature.

We only care when we are aware.

Analysis of humpback whale (Megaptera novaeangliae) behavioural response to two acoustic deterrent devices (ADDs) in their Icelandic feeding ground

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Cetacean entanglement in fishing gear is of global concern and recently focus has been put on mitigation of such events particularly for large whales such as the humpback whale (*Megaptera novaeangliae*). Entanglements can have detrimental impacts on individuals and populations, as well as on fishers. In Icelandic waters there are approximately 12,000 humpback whales during the summer feeding season, as well as a large commercial fishing fleet utilizing many types of gear. It is estimated at least one-quarter of these whales have been previously entangled. This study conducted behavioural response tests on humpback whales in Skjálfandi Bay and Eyjafjörður, Northeast Iceland, to two acoustic deterrent devices (ADDs): Future Oceans Whale Pinger (WP) (3kHz, 145dB, 5s interval, 400ms duration) and Lofitech Seal Scarer (SS) (14.5kHz, 189dB, 0.6-90s interval, 550ms duration). The individual focal whale for each test was tracked from a boat approximately 100m away using GPS, angle, and range-finder distance for 30 minutes prior to deployment of one device (PrT), for 15 minutes of exposure to an active device (T), and for 30 minutes after exposure (PoT). A total of 9 WP and 7 SS tests could be utilized. Available behaviour data in the forms of average dive time, breathing rate, speed and directivity were analyzed, as well as feeding behaviour for the WP tests, using mixed effect models in R. Results for the WP tests showed that the probability that an observed surfacing event is accompanied by feeding behaviour is significantly lower during the T phase than during the PrT and PoT phases. For dive time, breathing rate, speed and directivity we did not find a significant response that was consistent across individuals for either device. Continued testing of humpback whale response to sound and use of ADDs on commercial fishing gear would be useful in further determining the potential of such devices for entanglement mitigation.

Cetacean distribution in relation to environmental parameters between Drake Passage and northern Antarctic Peninsula.

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The Drake Passage is a dynamic oceanographic region influenced by the main frontal systems of the Southern Ocean, with little information about cetacean distribution and their relationship with environmental parameters. This study explored the use of Generalized Additive Models (GAM) to model the relationships of some cetacean species according to oceanographic (chlorophyll *a* and sea surface temperature) and a suit of physiographic (depth, bottom topography, distances from lands and fronts) variables adjacent to the Antarctic Peninsula and Drake Passage during the austral summer. The results suggest that the physiographic features, mainly the distances from land, were the most significant parameters related to the presence/absence of cetaceans. Distances from Antarctic Peninsula and the Polar Front influenced the occurrence of many species. Sea surface temperature showed an effect only on humpback whale presence around lower temperatures, and chlorophyll *a* was not found to have a significant relationship with either cetacean species. Most of the species occurred mainly South of the Polar Front, with killer, minke and humpback whales mostly occurring in coastal areas, whereas conversely fin and sei whales occurred more frequently in offshore waters. The southern bottlenose whale seems to occupy a wide range of latitude. Hourglass dolphin and long-finned pilot whale are species frequently occurring in the Drake Passage, suggesting their northernmost and southernmost ranges, respectively. We encourage further dedicated cetacean surveys in this peculiar dynamic region, based on *in situ* oceanographic data and krill acoustic sampling, and either taking into consideration cetacean species density or abundance.

Changes in bottlenose dolphin distribution patterns in response to harmful algal blooms and hypoxic events in a southwest Florida estuary

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Bottlenose dolphins (*Tursiops truncatus*) in the Charlotte Harbor/Pine Island Sound (CHPIS) estuarine complex along the southwest coast of Florida are typically year-round, long-term residents. This estuary occasionally experiences extreme environmental perturbations such as red tide (*Karenia brevis*) harmful algal blooms (HABs), as well as seasonal hypoxic events. During 2001-2006, boat-based photo identification surveys (338 boat-days, 1957 sightings) along repeated transects were conducted to estimate abundance, trends and patterns of distribution during Jan/Feb and Sep/Oct of most years. Hypoxic conditions were documented yearly during the rainy season (Jul-Oct) in northeast CHPIS near two river mouths. Fewer dolphins were observed during surveys in northeast CHPIS during these hypoxic events compared to winter surveys. During 2005-2006 a severe red tide HAB occurred along the central and southwest coast of Florida including the CHPIS inlet passes, and large fish kills were observed. Fewer dolphins were observed near these passes during Sep/Oct 2006 compared to non-HAB survey years. Dolphins were more concentrated in central CHPIS during these two concurrent environmental perturbations in Sep/Oct 2006, unlike other survey periods, possibly as a result of changes in prey availability and distribution. Following this red tide HAB event, we received increased reports about begging or patrolling dolphins. This suggests that such environmental disruptions not only change dolphin distribution but may also increase the frequency of human-dolphin interactions. Public outreach about safe boating and angling around dolphins to area stakeholders would be beneficial, especially following red tide events.

A whole genome study of bottlenose dolphins reveals signatures of selection associated with resistance and susceptibility to cetacean morbillivirus.

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Cetaceans are increasingly faced with a number of natural and anthropogenic stressors that can drive their population demography and evolutionary processes. Of these stressors, cetacean morbillivirus (CeMV) has emerged as one of the most significant viral threats to cetaceans worldwide contributing to the death of tens of thousands of individuals within multiple species. Variability within genes are known to influence host susceptibility and resistance to disease, and it is therefore important to identify genetic variants which impact on the ability of individuals to survive CeMV outbreaks and for populations to persist. Initially we sequenced a reduced representation of the genome in survivor and non-survivor bottlenose dolphins of a 2013 CeMV outbreak in southern Australia. Out of 35,493 single nucleotide polymorphisms (SNPs), association analyses identified five candidate genes associated with resistance and susceptibility to CeMV. These genes have functions related to stress, immune and pain responses. We now build on this study by sequencing the whole-genome of a larger number of survivors and non-survivors of the outbreak, to test for differences in genetic variants between the two groups for genes known to be associated with morbilliviruses and immune responses in other species. The whole genome dataset consists of 16,658,049 high quality SNPs. Association analyses found significant allele and genotype frequency differences between survivors and non-survivors at 471 SNPs located on 70 different scaffolds. Annotation of the candidate SNPs revealed several additional genes associated with host immunity and biological processes. This study provides vital information about genes involved in host resistance and susceptibility to CeMV and will contribute to a better understanding of disease evolution. In addition, biomarkers can be developed to assess potential genetic risk factors in other cetacean populations and species.

Marine mammals and argos satellite telemetry

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The Argos satellite system is used since 1978 by the biologists for tracking high-migratory animals and collecting biodata.

The Argos biotelemetry is used specifically by marine mammals' biologists among other scientific methodologies (photo-ID, genetics, habitat models, oceanographic environment). Many species of baleen whales, toothed whales, dolphins, porpoises, belugas, pilot whales, dolphins, pinnipeds, orcas,

narwhals, etc. have been tagged and provided huge amount of data allowing to:

- Observe large-scale movements of cetaceans, map hot spots and delineate vulnerable areas
- Understand behavior processes through Argos-transmitted data such as depth dive, accelerometry, and parameters of surrounding waters such as temperature, salinity, fluor, oxygen.

Beyond marine mammalogy and research goals, these data are used to provide stakeholders with evidence showing the necessity to establish conservation measures, establish and monitor marine protected areas.

The talk will present the present and future Argos satellites constellation (20 nanosatellites operational in 2022, allowing an improving revisit time and a downlink capacity), the Argos-tracked animals main figures, statistics and maps on around 15,000 marine mammals tracked among the 77,000 Argos wildlife platforms, 3,000 Argos programs deployed since more than 10 years, and some interesting case studies from some Argos marine mammals' important scientists.

Manatee/green sea turtle behavioral interactions: Interspecies play?

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The eminent neuroethologist, Theodore Bullock, proposed that play and complexity of social interaction are candidates for establishing a more complete view of animal intelligence than provided by traditional learning theory. Here, we investigated play in an adult, male Florida manatee (*Trichechus manatus latirostris*) and adult, male green sea turtle (*Chelonia mydas*) housed together at Mote Marine Laboratory where they were observed to interact frequently. Video analysis indicated that both animals initiated interactions including flipper and torso touching, face-to-face touching, tandem swimming, and body riding (turtle on manatee and manatee on turtle). Although these activities might be attributed to a variety of motivations (e.g., affiliation), the complexity and eccentricity of the behaviors suggests another alternative: play. The behaviors are consistent with Gordon M. Burghardt's five criteria for play: 1) Limited in immediate function; 2) Spontaneous, apparently intentional, or autotelic ("done for their own sake"); 3) Structurally or temporally different than ethotypic behavior; 4) Repeated but not rigidly stereotyped; 5) Initiated in an apparently relaxed field (e.g., free from hunger, adverse health, or stressful conditions) or competing systems (e.g., feeding, mating, predator avoidance). This report provides unusual examples of play by both manatee and turtle. Furthermore, it provides rare documentation of manatee and turtle interspecies play. Taken within Bullock's framework, these observations provide an unexpected example of cognitive sophistication not traditionally attributed to manatees and sea turtles.

Simultaneously detecting and classifying tonal and pulsed marine mammal sounds over a very wide range of frequencies in a single acoustic analysis system

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Detection and classification of marine mammals using passive acoustic monitoring is traditionally conducted on a species-by-species basis using separate algorithms for each species' characteristic calls. When an application requires the detection of many species simultaneously, this approach becomes inefficient at best, and impractical at worst. The low-frequency detection and classification system (LFDCS) uses (1) pitch tracking to detect and characterize tonal sounds in a recording or real-time audio stream, and (2) a separate discriminant function analysis (DFA) to classify sounds by call type and species, allowing the detection and classification of many species simultaneously in a single processing run. The LFDCS, like most tonal marine mammal detectors, relies on spectrograms produced on a linear frequency scale, despite the fact that sound is both produced and perceived on a logarithmic frequency scale. This limits the band of frequencies that can be effectively monitored to roughly 4 octaves, yet marine mammals make tonal and pulse sounds over a range of 12+ octaves. To overcome this limitation, I have implemented an efficient algorithm to create spectrograms based on the constant-Q transform (CQT), a technique to estimate spectral content on a logarithmic frequency scale. The same pitch tracking and DFA approach used in the LFDCS is used on CQT-based spectrograms to detect, characterize, and classify tonal sounds from 15 Hz to 50 kHz (e.g., baleen whale moans to dolphin whistles). The system also incorporates a detection (Teager-Kaiser energy operator) and classification (DFA) system for pulse

sounds (e.g., echolocation clicks, minke whale pulse trains, walrus knocks) that takes advantage of the wide-band processing required for the creation of CQT-based spectrograms. The new system is implemented on a desktop computer for processing archived recordings and will be implemented on the digital acoustic monitoring (DMON) instrument for in-situ real-time detection and classification from autonomous platforms.

Stereotypy of whistles: Can whistles be used to estimate dolphin abundance?

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Whistles have been studied extensively for both wild and captive dolphins. They are used in the communication between individuals, to maintain contact within individuals of a herd, and to coordinate herd movements, having some whistle types that are an individual distinction or signature. However, little is known on how whistles can be used to ascribe individuals. Therefore, the present study is focused on determining the stereotypy of the most frequently emitted whistles by four captive bottlenose dolphins, *Tursiops truncatus*, housed in two different marine parks. Stereotypy was computed by changing the similarity index while classifying whistles into whistle types using Matlab BELUGA and ArtWARP. The whistling dolphin identity was determined using the method described in López & Bazúa (2010). Results indicate that signature whistles have a similarity index greater than 94-95%, therefore, allowing to assess the minimum number of whistling dolphins in a pod that emit signature whistles. This is especially important in the wild, where in some occassions, it is very difficult to assess how many individuals are present. This very simple method promises to be useful to quantify the number of signature whistles from underwater recordings, and to relate it with the possible number of dolphins present. Further work will include testing this method with wild bottlenose dolphin recordings. It is necessary to implement such methods to better understand how dolphins are using whistles, since acoustic communication is the most important sense in dolphin species. [Work supported by PAPIIT & PASPA-UNAM]

Fine-scale distribution of harbour porpoise Phocoena phocoena within a coastal Marine Protected Area

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The designation of protected sites for cetaceans has been largely shaped by patterns in site fidelity, often favouring species with clear residency patterns or highly localised breeding and foraging areas. Conservation of the harbour porpoise Phocoena phocoena, a species that does not typically exhibit strong patterns in site fidelity, has been challenging. However, studies have reported predictable foraging hotspots that may be suitable for long-term monitoring through an MPA framework. The objective of this study was to conduct static acoustic monitoring within the Skerries and Causeway Special Area of Conservation (SAC), suitable for the assessment harbour porpoise occurrence at a fine spatio-temporal scale. The study aimed to determine the degree of heterogeneity at this site, identifying any localised hotspots, and from this discuss the capability of land-based visual techniques for ongoing monitoring. Generalised Addictive Mixed Model (GAMM) revealed site specific differences in harbour porpoise occurrence with strong cyclical patterns attributed to tidal preferences. Foraging click trains were evident at all sites and so while harbour porpoise are likely foraging throughout the SAC, the significant difference in overall detection rates is suggestive of localised hotspots. The fine-scale (< 5 km) patterns in harbour porpoise occurrence found in this study can be used to inform MPA management through the timing of human activities, for example by avoiding peak porpoise times or facilitating local eco-tourism ventures. Further investigation on the seasonal persistence of the identified hotspots is recommended as part of long-term monitoring within this protected area.

Predicting cetacean abundance and distribution in a changing climate.

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Substantial changes in abundance and shifts in distribution as a result of a warming climate have been documented for many marine species, but opportunities to test our ability to forecast such changes have been limited. In 2014, waters in the California Current Ecosystem (CCE) became anomalously warm as an unprecedented marine heatwave spread over the area. The profoundly altered ocean conditions provided a unique opportunity to evaluate whether species distribution models (SDMs) could accurately predict changes in marine mammal abundance and distribution during a period with unusually warm ocean temperatures. We constructed SDMs based on 1991-2009 CCE sighting data and environmental output from a regional ocean model for eight cetacean species with a diverse range of habitat associations. Model selection was based on established metrics including AIC and root-mean-squared error. Models were then used to forecast species abundance and distribution patterns during 2014, and predictions compared to actual 2014 cetacean survey sighting data to assess model performance. Ratios of model-predicted abundance to design-based estimates were close to 1:1 for all but one species and accurately captured changes in the number of animals in the study area during the anomalous year. Predicted distribution patterns also showed good concordance with the actual 2014 survey observations and captured substantial shifts in the distribution of some species. Our results indicate that models of cetacean-habitat relationships built on two decades of survey data were sufficiently robust to capture changes in abundance and shifts in distribution under anomalous conditions, for both cool and warm temperate species. This is likely because the models were based on long-term survey data collected during periods that encompassed a large range of environmental variation. They also revealed species-specific responses to warming ocean waters, enhancing our understanding of the effects of climate change on cetaceans and other marine predators in the CCE.

Late evoked potentials in porpoises speak against a per-click view of echolocation and suggest potential for electrophysiological audiograms at low frequencies

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Actively sensing animals like odontocetes offer an opportunity to study the control of sensory streaming and the type of control loop they employ for perceptually organizing and negotiating obstacles in the environment and for finding prey. Within the field of odontocete biosonar, an open question is whether returning echoes are evaluated on a click-by-click basis or if a running central evaluation that incorporates several clicks in shaping the animal's perceptual organization of their complex echo scene. During the buzz phase of small odontocetes inter-click intervals (ICI) may be as low as 2 ms, which fact seemingly precludes the possibility of individual click processing. However, the time separation between events that would be necessary for discrete click processing is unknown. Here we address that problem by studying the low-frequency auditory evoked potentials (AEP) in a stationary porpoise presented with clicks at ICIs of 0.5-1 s. By using low presentation rates and averaging over tens of sessions, we found a consistent late component in the AEPs occurring at latencies out to at least 150 ms. We argue that these late responses represents cortical evoked potentials, whereby 150 ms should form a lower limit to the ICIs at which click-by-click processing of echoes could take place. The ICI of echolocating porpoises is usually much lower than 150 ms (2-50 ms), so it appears that they do not process echo information cognitively before emission of the next click. The slow, presumably cortical, components of the AEPs hold an exciting potential for assessing the audiogram of odontocetes electrophysiologically down to frequencies well below what is usually thought possible with traditional amplitude modulated tonal stimuli, usually assumed to be limited to frequencies above several kilohertz.

To be seen or to be heard? Combining passive acoustic monitoring and visual boat-based observations for studying killer whale depredation.

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Within the French economic exclusive zones (EEZ) of Crozet and Kerguelen Islands (Southern Ocean), longline fisheries are highly impacted by the depredation of the Patagonian toothfish mainly by killer whales. Within the purpose to mitigate depredation, it is crucial to understand how they

depredate on longlines underwater. However, those interactions have mostly been assessed from visual observations from the fishing vessels during the hauling of longlines. Fortunately, killer whales rely on acoustic signals for both communication and foraging. In this context, passive acoustic monitoring is a good approach to assess the temporal and spatial behaviour of cetaceans around fishing gears. Here, near Crozet islands we deployed one hydrophone on a longline to record all fishing operations in the vicinity. The aim of this study is to improve the estimation of interactions using acoustic encounters of killer whales (echolocation and vocalization). Thus, 400 hours of recordings collected among 11 deployments of the hydrophone have been manually processed to assess killer whales acoustic encounters. In our study, killer whales were acoustically detected only on 6 deployments. Acoustic encounters of killer whales around the hydrophone were compared with visual observations from the fishing vessel during the hauling. Almost 80% of the longlines were hauled in presence of killer whales at the surface, and for the half, acoustic encounters have been also detected in the vicinity of the hydrophone with a maximum detection range estimated between 5 and 10 km. Moreover, almost 20% of killer whale acoustic encounters have been detected during hauling sessions with no visual observation from boats. This revealed that killer whales may remain near some of the longlines instead of following the boat. Since echolocation signals (clicks and buzzes) were recorded during these events, we strongly suggest that killer whales were foraging or even depredating.

Application of Artificial Intelligence to the photo-identification of common bottlenose and Risso's dolphins.

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Photo-identification of cetaceans is labor-intensive and time-consuming particularly in the case of large studies when manually performed. To that regard, Artificial Intelligence (AI) can support photo-identification studies with an extensive variety of statistical methods. The unique element of this work is the development of an AI-based system which makes decisions in terms of photo-identification not differently than a human mind would, thus providing users with an automated dorsal fin cropping and an individual-recognition pipeline for cetaceans. Both machine and human intelligences process symbols to interpret and learn from data. The developed system automatically identifies two categories of symbols: a) internal descriptors on the dorsal fin surface and b) outline descriptors, which are key-points over the fin contour. Internal and outline descriptors are both used for individual recognition in the classification process. The species of interest are the common bottlenose dolphin *Tursiops truncatus* and the Risso's dolphin *Grampus griseus*. Sighting data have been acquired in the Gulf of Taranto in the Northern Ionian Sea (North-eastern Central Mediterranean Sea) and in the coastal waters around Pico Island in the Azores Archipelago (Eastern Atlantic Ocean). The accuracy of the dolphin photo-identification, computed by the proposed system, varies between 85% and 95%. Experimental results highlight that the developed automated system supports the work in terms of photo-identification of dolphin species, as essential prerequisite for insight studies on their spatial distributions, habitat uses, residency and migration patterns. Moreover, to make the proposed system accessible to a wider users' community, we have also invested on the development of a well-documented graphical interface, together with a digital platform to smartly collect data.

Isometric relationships in humpback whales studied using drone-based imaging

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Assessing body size in free-ranging cetaceans is important for a number of scientific purposes. One approach is to take photogrammetric measures of visible body parts at the surface, such as the fluke, in order to extrapolate the individual's estimated body length from previously an established allometric relation. In humpback whales (*Megaptera novaeangliae*), a linear relationship has been reported between fluke width and body

length, but this was largely based on a heterogenous sample of stranded individuals (n=45) containing many new-born calves. Here, we used an unmanned aerial vehicle (drone) to obtain aerial photographs of free-ranging Northern humpback whales. We managed to photograph and extract trait measures of N=55 individuals, which allowed us to reassess the allometric relationships between body size and different trait variables. For fluke size, our data largely confirmed the historic data and showed a strong linear regression between body size and fluke width ($R^2 = 0.94$, $P < 2e\text{-}16$) which also revealed a strong isometric relation between body size and fluke width ($p < 2.2e\text{-}16$). We then expanded our trait analysis to include head surface, pectoral and dorsal fin length, and blowhole to dorsal fin distance and discuss our findings in light of eventual physiological constraints i.e. which would predict non-isometric (i.e. allometric) relationships. Our study highlights the promise of using unmanned aerial vehicles in morphometric studies and applied problems that require estimating body size of free-ranging cetaceans.

Variation, selection, and heritability of foraging strategies and their influence on lifetime reproductive success in northern elephant seals.

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A fundamental question in biology is which behavioral traits confer fitness advantages and whether those traits are passed onto offspring. Our aim was to explain the great variation in lifetime reproductive success (LRS) of female northern elephant seals, *Mirounga angustirostris,* by examining their at-sea behavior. We sought to determine whether diving behavior, foraging routes and location, and life history phenology contributed to LRS. We examined the diving records of 271 instrumented females whose LRS was determined independently and varied from 0 to 20 pups produced. No ready explanation for the drastic individual differences in LRS emerged from the diving behavior or life history phenology data. However, we found a strong interactive effect of birth year and Pacific Decadal Oscillation (PDO) phase on how tracking route related to lifetime reproductive success. For cohorts that experienced enhanced offshore productivity (PDO+) during their first trip to sea (2003, 2005), the offshore strategy was associated with high lifetime reproductive success. Conversely, for cohorts that experienced enhanced coastal productivity (PDO-) during their first trip to sea (2000, 2002), the coastal strategy was associated with high lifetime reproductive success. We found no evidence for heritability of foraging route in mother-pup pairs ($N = 10$); pup migration routes were no more similar to the routes of their mothers than to random seals. We conclude that the climate phase at birth is an important determinant of successful initial foraging and that causes for the great variation in LRS warrant further study.

Determinants of dispersal and phylogeographic history of a highly mobile cetacean species: The North Atlantic harbour porpoise.

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Understanding the determinants of individual dispersal, population structure, and evolutionary history can provide insights about how species will evolve with climate change. However, such a task is complex for highly mobile marine species such as cetaceans for which it is intuitively difficult to infer what could limit their dispersal. The harbor porpoise (*Phocoena phococena*) is widely distributed in the North Atlantic. Its biogeographic history has been shaped by environmental variation during the last Glaciations with the divergence of three ecotypes (or sub-species) in the Eastern North Atlantic (ENA). However, we still do not know the degree to which populations in the ENA are connected to those in the Western North Atlantic (WNA), what environmental determinants drive the dispersal of porpoises, and whether distinct ecotypes exist in the WNA. Here we analyze the genetic diversity of 10 microsatellite loci and one-quarter of the mitogenome for an unprecedented sampling of 1,533 individuals. Using spatially explicit population genetics approaches, we investigated fine-scale population structure over the entire North Atlantic. Our study suggests that porpoises from the WNA and ENA are part of the same "*continental shelf ecotype*" that stretches from the northern Bay of Biscay to the WNA. We identified a clear signal of restricted dispersal in the

mitogenome data supporting previous evidence of female philopatry. We also discovered a cryptic divergent mitochondrial lineage in one individual from Western Greenland suggesting a fourth distinct ecotype may exist. Finally, we reconstructed the phylogeographic history of these porpoises using coalescent simulations of population evolution, shedding light on the likely scenarios that shaped the current pattern of genetic diversity. These results provide key insights into the factors and processes shaping population structure in this species and will help model its evolution in the forecasted climate changes.

The humpback whale sentinel program reveals 2017 as an anomalous year in the eastern Antarctic Sea-ice ecosystem

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In 2017, the world observed some of the most dramatic changes recorded in Antarctica in modern history. July 2017 saw 10% of the Larsen C ice-shelf cleave off as a massive iceberg. The year continued with the appearance of a 300,000 m^2 polynya in the winter sea-ice off east Antarctica, and summer sea-ice coverage was the lowest on record, 27% below the mean annual minimum. Southern hemisphere humpback whales (*Megaptera novaeangliae*) were recently implemented as sentinels of the Antarctic sea-ice system owing to their dependence upon sympagic Antarctic krill (*Euphausia superba*) and extreme energetic adaptations. To date, populations migrating to Colombian (G), Brazilian (A), western (D) and eastern (E1) Australian breeding grounds have been included into this Southern Ocean Observing System (SOOS)-endorsed effort for circum-polar surveillance. The longest continuous record of annual sentinel parameter measurements (11-years) is available for the E1 stock. Temporal analysis of blubber biochemical signals, histology, and the demography of the migratory cohort of the E1 population, revealed 2017 to be an outlier. Biopsied blubber samples had high proportions of the fatty acid 21:5ω3, which was not present in whales sampled in other years. The inverse Adiposity Index (AI^{-1}) of southward migrating whales was the second lowest on record, 15% below the mean for this sampling time-point. Finally, the sex ratio of the migratory cohort showed a greater than average skew towards males within precisely comparable time windows; potentially indicating missed or delayed migration among reproductive females as an energy conserving strategy. The role of Antarctic sea-ice extent, and the timing of sea-ice break-up, in influencing krill abundance and availability to predators remains an active area of research, and one which carries clear consequences for Southern Ocean baleen whale populations. Results presented here lend strength to the use of migratory baleen whales for capturing present-day changes in the remote Antarctic ecosystem.

Balancing the risk: Harbour porpoises respond to piling and vessel activities during offshore windfarm construction.

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Offshore windfarm (OWF) developments are expanding, requiring assessment and mitigation of construction activities. Typically, this focusses on pile-driving, as intense impulsive noise elicits adverse behavioural responses in marine mammals. However, construction activities such as jacket, turbine and cabling installation also change acoustic habitats through increased vessel activity.

We quantified variation in harbour porpoise occurrence and foraging activity over the two-year construction of Beatrice OWF in Scotland, and related this to changes in vessel activity and the acoustic environment. Following a BACI design, arrays of echolocation click detectors (CPODs) were deployed in 25km by 25km impact and reference blocks throughout construction. Echolocation clicks and buzz inter-click intervals were used to investigate porpoise occurrence and foraging activity respectively. In parallel, deployments of acoustic recorders enabled us to measure broadband noise levels in different construction phases, identify acoustic signatures of key activities and relate these to variations in porpoise occurrence and activity. To characterise vessel activities at the site, AIS vessel-tracking data were integrated with engineering records. Generalised linear mixed effect models were used to describe relationships between porpoise occurrence and foraging activity and different construction works.

A decline in porpoise occurrence was observed in the impact block during the 2017 construction phase, but short-term responses to piling events did not result in broad-scale displacement. Higher probability of buzzing at the site highlighted a change in activity budgets, suggesting porpoises maximised foraging activity during shorter periods spent in exposed areas. These same patterns were observed in 2018 during the jacket and turbine installation.

These findings suggest that assessments should account for all construction activities that may result in variation in local soundscapes, particularly where efforts to mitigate one noise source (e.g. piling) may increase other vessel-based activities.

Exploring influences of lower-frequency Acoustic Deterrent Devices (ADDs) on harbour porpoise in Scottish coastal waters.

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Acoustic Deterrent Devices (ADDs) are widely used to deter pinniped depredation from finfish farms by emitting loud, aversive sounds, which may also impact non-target species such as harbour porpoise (*Phocoena phocoena*). One potential method of reducing ADD noise impacts on species such as porpoises involves lowering output frequencies from typical ranges of 10-20 kHz down to <2 kHz, where porpoises' hearing sensitivity is poorer compared to pinnipeds.

We compared responses of wild harbour porpoises to experimental playbacks of an artificial ADD-like sinusoidal tonal burst signal (RMS source level 154-170 dB re 1 µPa-m) transmitted at two frequency ranges (8-18 kHz [HF] and 1-2 kHz [LF]). Signals were transmitted from a salmon farm in Bloody Bay (Sound of Mull, Scotland, UK). An array of 22 C-POD click train detectors was deployed to 5 km from the source and farm. Signal playbacks varied randomly between HF- and LF-signals and a silent control, and occurred over 33 days (08/09-11/10/2016). During this period, 138 experimental playback bouts occurred, including 53 HF-signals, 38 LF-signals and 47 silent controls. C-POD data were used to infer porpoise presence and analysed using nonparametric Kruskal-Wallis tests and GAM-GEE models to evaluate effects of different signals and environmental covariates on porpoise detection probabilities.

At most C-PODs, porpoise detection rates were significantly lower during both HF- and LF-signal playbacks relative to silent controls. GAM-GEE modelling identified "ADD-like signal presence" as an important factor determining porpoise detection probabilities at distances up to 800 – 1000 m from source. At greater distances, other covariates (e.g. day-night, ebb-flood and spring-neap cycles) dominated.

Based on these results, widespread application of lower-frequency ADDs with signal characteristics similar to those tested would, by themselves, be unlikely to significantly reduce risk of acoustic impacts on harbour porpoises in Scottish waters, when compared to conventional ADD signals.

Energy balance effects of persistent organic pollutants in marine mammals: Linking in vitro experiments on blubber tissue function with mass change trajectories in grey seals.

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Lipophilic environmental pollutants can alter adipose function and hormone levels, but impacts on whole animal energy balance are poorly understood. We investigated whether blubber persistent organic pollutants (POPs) influence body mass trajectories during suckling or natural fasting in wild grey seal pups through impacts on adipose tissue metabolic characteristics, thyroid hormone (TH) levels and blubber TH sensitivity measured in vitro. Pups with higher blubber glucose uptake rates gained mass faster during suckling (LM: $F_{(4,52)} = 6.54$; $p = 0.002$; $R2 = 0.33$; $T = 2.19$, $p = 0.032$), in addition to established effects of maternal mass, sex, suckling duration and birth mass. T3 concentrations were negatively related to blubber polychlorinated biphenyl (PCB) levels. Blubber explants increased glucose uptake in response to acute T3 treatment (GAMM: $T = 1.97$;

p = 0.05; R2 = 0.27), but not in response to overnight PCB exposure (T = 0.47; p = 0.63). However, PCBs abolished the acute response to T3 (T = 0.47; p = 0.63). Dioxin-like-PCBs may slow mass gain by reducing blubber glucose uptake directly, and by lowering T3 levels and blubber T3 sensitivity. Dichlorodiphenyltrichloroethane (DDT) and its metabolites (DDX) were associated with lower efficiency of mass transfer from mother to pup (LM: F (5,78) = 23.07; p < 0.001; R2 = 0.57; T = 2.39; p = 0.019). Fasting pups that were heavier at weaning and had higher blubber DDX levels lost mass faster. These findings are consistent with a positive effect of blubber DDX on lipolysis in vitro. Our data show how negative effects of POPs on fat tissue function, measured in vitro, can be linked to whole-animal mass change trajectories during key life history stages. Legacy contaminants, even at doses below toxic thresholds, may have ongoing ecological consequences for marine mammals through impacts on energy balance.Lipophilic environmental pollutants

Marine associated bird and mammal habitat use at the Five Finger Light.

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In summer 2017 I studied the abundance and distribution of marine mammals and associated birds at the Five Finger Lighthouse in Southeast Alaska. My objectives were (1) to identify the areas of highest habitat use by species of conservation concern, (2) to make recommendations for an ecosystem-based management plan for the island, and (3) to initiate a citizen science project supporting continued place-based research and conservation. This study documented seven species of marine mammals and 20 taxonomic groups of birds derived from 110 field surveys. My analysis found higher relative abundance and greater biodiversity of both birds and marine mammals on the south and west facing sectors of the island compared to the north and east facing sectors. I attribute this to the greater habitat complexity on the south and west facing sectors that comprise a near-shore reef, a mixed kelp forest, and a channel between the reef and rocky cliffs, areas used extensively for foraging, nesting, traveling, socializing, and resting by many of the documented species. These findings provided the basis for recommendations to avoid development and to minimize anthropogenic disturbance on the southern and western portions of the island including the adjacent reef and channel. In 2018, novel results from this study were used to prevent disturbance to harbor seals (*Phoca vitulina*) during pup rearing season, a species of high conservation concern in Alaska both due to declining numbers and importance to traditional subsistence harvest practices. As both the Five Finger Lighthouse ecosystem and management continue to evolve in response to changing environmental conditions and human interests, this study also established a baseline for future study that will inform future adaptive management, document changes over time, and engage community stakeholders in science and conservation.

Insights into habitat use and identification of critical areas for two endangered populations of franciscana dolphins (Pontoporia blainvillei) in southeastern Brazil.

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The franciscana (Pontoporia blainvillei) is considered the most threatened small cetacean in southwestern Atlantic because of high range-wide bycatch mortality. Franciscanas in Espírito Santo and Rio de Janeiro States, southeastern Brazil, comprise two isolated populations in areas known, respectively, as Franciscana Management Area (FMA) 1a and 1b. Serious concerns regarding the status of these populations have been expressed due to their geographic isolation, genetic distinctiveness, and low density. Here we present data on habitat use and identification of critical areas for franciscana conservation achieved through three summer aerial surveys (2012, 2017 and 2018). Design-based line transect surveys were carried out by four experienced observers using a twin-engine airplane. Fifty-seven franciscana sightings form the database of this study. Habitat preference by depth was investigated by correcting the franciscana encounter rate by the available area within each 10m-depth interval. Franciscanas in FMA1a presented extremely coastal habits in summer, with 80% of the population being distributed less than 3nm from the coast. Habitat

use of the 0-10m interval is 1.25 greater than the 10-20 interval. We identified that 50% of the FMA1a population is concentrated in only 20% of their available distribution area. This small concentration area (500km2; 30km of coastline) is located south of Doce River (19o39´S) and represents great conservation potential. Franciscanas in FMA1b shows a slightly more spread inshore-offshore distributional pattern, with 45% of the population using waters less than 3nm from the coast. Franciscana utilization of the 0-10m interval is 1.33 and 5.6 greater than the 10-20 and 20-30m interval, respectively, even though it represents only 10% of the surveyed area. The area between Cape São Tomé (21º59´S) and Carapebus (22º13´S) is critical since it concentrates 70% of this population. Our findings highlight that the conservation of these franciscana populations depends on robust measures to protect the coastal environment.

Bottlenose dolphin, Tursiops truncatus, predator – prey responses to red tide harmful algal blooms.

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Red tide blooms, caused by the toxic dinoflagellate *Karenia brevis*, occur regularly along Florida's west coast and often result in massive fish kills and marine mammal mortalities. Previous research during an intense, protracted, and wide-spread bloom (2005-2006) showed decreases in fish abundance, species richness, diversity, and changes in community structure in Sarasota Bay, Florida. Concurrently, juvenile resident bottlenose dolphins, altered activity budgets, increased sociality, and expanded ranging behavior during bloom periods. The objective of this study was to determine the impact of a recent intense but relatively short-duration bloom (summer 2018 – winter 2019) on the fish community and on dolphin foraging in Sarasota Bay, Florida. Data on fish abundance, species composition, *K. brevis* cell densities, and water quality were analyzed to quantify changes in fish, and specifically dolphin prey, abundances, overall species richness, diversity, and community structure. Standardized dolphin survey data were analyzed to determine dolphin foraging encounters relative to *K. brevis* and fish abundance. During bloom conditions, fish abundances decreased significantly, species diversity increased, and community structure shifted due primarily to changes in temperature and *K. brevis* density. Preliminary analyses indicate that dolphin foraging behaviors were observed more often at locations lower in *K. brevis* density. Hot spot analyses will further explore spatial relationships between dolphin foraging encounters, *K. brevis* density, and fish abundance. These results support previous findings that recurrent *K. brevis* blooms likely play an important role in regulating fish communities, specifically by reducing fish abundances, and altering species diversity and community structure. Additionally, these analyses indicate that the recent 2018-2019 bloom event was a relatively less severe ecological disturbance than the 2005-2006 bloom. A better understanding of the patterns and processes of bloom disturbance, as well as the factors that contribute to ecosystem resilience, are essential for management and conservation.

Quantifying harbour porpoises foraging behaviour in CPOD data

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Harbour porpoises (Phocoena phocoena) are regularly monitored to assess how they are impacted by the construction and operation of offshore wind farms. A suitable method to do this is passive acoustic monitoring (PAM) by stationary hydrophones, for example CPODs. These devices provide information on echolocation click activity, which can then be analysed.

Prey occurrence is considered one of the main drivers in porpoise distribution and successful feeding is vital to the fitness and survival of individual porpoises. Information on foraging behavior, however, is difficult to obtain in the field, in particular as animals feed under water.

Harbour porpoise use narrow band high frequency signals in a sequence of clicks (called click trains) for echolocation, communication and foraging. The

different behaviors are characterised by the modulation in time lag between clicks (inter-click interval). For foraging behavior, the click train sequence is noticeably characterised by low inter-click intervals and a final increase in inter-click intervals. While such a train sequence can be resolved in recordings made on the animals, the detection of foraging events is more challenging for stationary hydrophones such as CPOD devices.

Using CPOD data collected in Dutch water during and after the construction of the Gemini wind farm (June 2015 to February 2016), the present study first investigated different data processing methods for the quantification of foraging behavior. The results indicate that a click-based classification provides the best results (as opposed to using click trains). This analytical tool was then applied to the entire data set to explore the potential applications of this method. The results show that foraging events could be detected in sufficient numbers to reveal patterns over time, such as correlation with pile driving activities, as well as to compare behaviour between CPOD stations.

NanoPAM: A novel low-cost acoustically networked system for marine mammal monitoring.

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Passive Acoustic Monitoring (PAM) has become an important tool to monitor cetacean occurrence and behaviour ecology by recording and analysing whistles, calls and echolocation clicks. Autonomous PAMs require retrieval to download data, are frequently lost and expensive, limiting their application. They are also limited to few species algorithms, sometimes not available to the user. To address this, we have developed NanoPAM, a novel low-cost acoustically networked PAM system which includes new hardware and software for l detection of echolocating cetaceans and acoustic transfer of data. NanoPAM consists of a broadband hydrophone (20 kHz – 160 kHz) and ultra-low energy digital signal processing to detect and classify cetacean click trains. The high level data from animal detections is then transferred back to shore in near real time via an underwater acoustic communication network, with each NanoPAM device acting as network router spaced by up to 2km. With a single WIFI connected surface buoy, networks of up to 256 devices may be deployed to cover an area of hundreds of km^2. The current NanoPAM development includes algorithms for harbour porpoise, common bottlenose and white-beaked dolphin and boat sonar and can distinguish between regular and foraging buzz clicks. Performance of NanoPAMs low energy algorithms compares favourably, in terms of detection and false positive rates, with state of the art click logging devices and offline processing of raw hydrophone recordings. Typical data transmissions consist of a 1s signal burst each hour, at a source level of 168 dB centred on 28 kHz, and the device may be programmed to wait until cetacean detections have stopped before transmitting. NanoPAM devices are designed to be moored on the seabed with no surface buoy required, can be quickly deployed due to their relatively small size and weight, and battery life will support up to 12 months deployment.

Exploring oceanographic influences on northern elephant seal pup and weaner strandings in California.

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The Marine Mammal Center (TMMC) responds to stranded marine mammals along 600 miles of the California coastline annually. These marine mammals are considered stranded when they are unable to return to their normal habitat or in need of medical attention. The present study explores the relationship between strandings of one of the most commonly admitted species to TMMC, the northern elephant seal (*Mirounga angustirostris*), and oceanographic conditions. Large-scale indices reflecting basin-wide conditions such as the Pacific Decadal Oscillation and the El Niñ̃o Southern Oscillation that contribute to long-term trends as well as more temporally and spatially localized features such as wave energy and water level are considered. While large storms increase incidents of maternal separation and elephant seal pup mortality at rookeries, the conditions that produce live elephant seal strandings outside of rookeries are less thoroughly understood. From 2007-2018, 447 elephant seals under one year of age that stranded within 30km of the nearest rookery in January-March are compared to wave energy determined from NOAA Wavewatch III model outputs. Strandings near the Point Reyes and Añ̃o Nuevo rookeries

in January and February when the majority of pups are still nursing show a strong relationship with wave energy while strandings near the San Simeon rookery in the same time period do not. In contrast, no conclusive relationship is found between wave energy and strandings in March when most pups have weaned from their mothers. A better understanding of the oceanographic conditions producing strandings will enable more informed planning with regards to stranding response in a future with a changing global climate.

Emerging pathogens and immunotoxic pollutants in cetaceans stranded along the coasts of Liguria, Pelagos Sanctuary, Italy

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Stranding events are generally multi-factorial and anthropogenic chemical pollutants can contribute to increase the susceptibility of marine mammals to infectious pathogens. The examination of cetaceans stranded in recent years along the coast of Liguria, North-Western Italy, Pelagos Sanctuary, has shown that infectious diseases represent an important cause of death. Moreover, several studies revealed toxicological stress by organochlorine (OC) xenobiotics in Mediterranean resident marine mammals.This study was focused on the pathogenic role of infectious agents in connection with toxicological stress, being also aimed at investigating the putative exposure sources.Between 2015 and 2018, 32 cetaceans were found stranded, mostly represented by *Stenella coeruleoalba* (81%) specimens. The National Reference Centre for Diagnostic Activities on Dead Stranded Cetaceans (C.Re.Di.Ma.) carried out necropsies and diagnostic investigations on over 80% of cases, including screening for the most relevant pathogens and specific characterization in case of positivity. OC levels were detected in the blubber from some specimens, being also evaluated for immunotoxicity with the help of theoretical reference models.Overall, 27 necropsies were performed (27/32, 84.3%) and it was possible to hypothesize the cause of death in 25 cases (25/27, 94.5%), mostly attributable to infectious diseases (20/25, 80%). In 10 individuals (10/20, 50%), serious coinfections were detected, involving cetacean viruses and/or pathogens either zoonotic (*Salmonella* 1,4,[5],12:i:- antibiotic-resistant strains, *Listeria monocytogenes*, *Brucella ceti* ST26) or indicative of terrestrial contamination (*Toxoplasma gondii, Aspergillus fumigatus*).High PCB levels were found in all individuals (12/12, 100%) and toxicological stress was evident in 50% of the cases, in particular in 5 out of 8 animals with coinfections (62.5%). Our results indicate a high level of contamination by terrestrial pathogens and OC xenobiotics along the North Western Italian coastline and demonstrate the importance of applying a multidisciplinary approach and of performing an adequate pathogens' characterization.

Conservation implications of loss of both blubber and muscle mass in cetaceans

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Marine mammals may lose body mass for many different reasons such as disease and reduced food availability due to overfishing and/or climate change. This loss in body mass may have detrimental effects on the animal's health and ability to survive. We studied the relative distribution of tissues (body composition) in different species of cetaceans to assess what occurs when an animal losses body mass. We performed mass dissections on multiple individuals with different body conditions from three cetacean species (*Stenella coeruloalba*, *Delphinus delphis*, and *Mesoplodon densirostris*). Our results indicated that animals in poor body condition lost both blubber and muscle mass. The animal with the worst body condition lost half of its blubber and muscle mass. A loss in blubber mass implies a loss in thermal isolation, which results in a higher metabolic rate for thermoregulation. Moreover, the loss in total body mass results in increased mass-specific metabolic rate, and the loss of muscle mass reduces the total O_2 store resulting in a reduction in the aerobic dive limit (ADL). This together reduces the foraging time. Consequently, an animal with poor body condition will have to spend more energy to obtain the same amount of prey at a higher energetic cost, resulting in greater body mass loss, leading to a snowball effect that can have fatal consequences. Reduction of the ADL might be more critical to deep diving species that unavoidably need longer dives to reach their prey. Loss of body mass may have a greater implication for individual animal survival and marine mammal conservation than previously thought, especially given the reduction of available food resources due to climate change and/or overfishing, and merits further investigations.

Elevated persistent organic pollutants exposure in St. Lawrence Estuary belugas (Canada): Relationships with lipid profiles and body condition.

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Exposure of St. Lawrence Estuary (SLE) belugas (*Delphinapterus leucas*) to elevated levels of persistent organic pollutants (POPs) was identified as an environmental stressor that may contribute to altering beluga health and potentially be associated with certain causes of death. Several POPs (e.g., PCBs and PBDEs) are known to disrupt thyroid functions and affect lipid metabolism and body condition. The objective of this study was to investigate the relationships between blubber POP concentrations (flame retardants and organochlorines), lipid profiles and body condition of SLE belugas. A secondary objective was to investigate the relationships between these variables and the cause of death of these animals determined by necropsy. Blubber concentrations of POPs and lipid compounds (fatty acids, phospholipids, acylcarnitines) were determined for 51 SLE beluga found dead between 1998 and 2016, and for which cause of death was established. Body length, body mass, age, sex and body condition (using a scaled mass index) were determined. Kruskal Wallis post hoc tests were used to determine significant differences between groups (sex, cause of death). SLE female belugas that died as a result of dystocia were younger and were in better body condition than other females, whereas those that died by starvation had a lower body condition index. SLE belugas that died from cancer exhibited greater concentrations of medium-chain fatty acids (C14:0, 16:0, 18:0) compared to beluga dying from other causes. Concentrations of PCBs and pesticides were 7 and 42 times greater in male than female SLE belugas, respectively. Covariance analyses were used to examine the relationships between these variables and POP concentrations, and Akaike Information Criterion to identify the variables related to the different causes of mortality. Preliminary findings suggest negative relationships between blubber POP concentrations and some of the lipid profile markers such as polyunsaturated:saturated fatty acid ratios, omega-6/omega-3.

Reproductive seasonality and breeding grounds of the fin whale, Balaenoptera physalus, in the Gulf of California.

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The fin whale, *Balaenoptera physalus*, is distributed in all of the world's oceans. Until now, only three resident populations are recognized: East Sea of China, Mediterranean Sea and the Gulf of California. The latter is a resident population considered genetically isolated, with an estimated population of 325 individuals (95% CI: 248-427), and a low genetic variability. This suggests that the population is vulnerable to genetic drift, anthropogenic events, disease, and changes in its habitat. Even though this population has been studied for 30 years, most of its reproductive strategies remain unknown, which makes studies about reproduction a priority. The objective of this study was to determine reproductive seasonality of the fin whale, as well as identifying possible breeding grounds in the Gulf of California, through the measurement of steroid hormones in fin whale biopsies and the analysis of mother-calf sightings. Skin biopsies were obtained from field work during 2015-2018 along the gulf. Blubber was used to measure 10 steroid hormones through liquid-liquid extraction, followed by high precision liquid chromatography-tandem mass spectrometry. Skin samples will be analyzed to determine sex. Testosterone, progesterone, 17B estradiol, androstenedione, aldosterone, 17 hydroxyprogesterone, cortisol, cortisone and corticosterone were detected and quantified using 50 mg blubber samples (Extraction efficiencies: 63-89%; RSD: 0.71-18%). Progesterone peaks and concentrations coincide with pregnant beluga whales, which could indicate pregnancy in fin whales. Once the sex of the individuals is known, statistical analysis will determine if hormone levels change throughout the year. The analysis of mother and calf sightings suggest a higher number of calves in the winter (January-April; $U=12,271$, $p<0.05$) and breeding grounds in the Southwest part of the gulf, especially in Bahia Loreto-Bahia La Paz corridor ($U=11,208$, $p<0.05$). Additionally, re-sighting of mothers during different years suggest a site fidelity in the breeding ground.

CARIMAM project: Adaptation and development of standardized protocols for the study of marine mammals in a Caribbean context.
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The Agoa Sanctuary (second largest MPA in France) is leading an INTERREG Caraibes project called CARI'MAM (Caribbean Marine Mammal Preservation Network). This project aims to develop a network of MPAs dedicated to the conservation of marine mammals in the Caribbean, a veritable hot spot of biodiversity suspected to host up to 31 cetacean species.

The technical objective is to standardize scientific protocols and develop common management tools. In an international context with strong inequalities and various levels of knowledge, it is a challenge to standerdize methods that accord the needs and possibilities of all.

Several methods ranging from passive acoustic monitoring to photo-identification are adapted and used by several territories to study the diversity and seasonality of species in order to adapt the associated management measures (eg periods and locations of seismic campaigns). Given the high number of islands, the large influx of data and the need for constant analysis for comparisons, tools for assisting standerdized data entry and artificial intelligence algorythms were favored by valuing as much as possible pre-existing tools.

High re-sighting rate and residency time of humpback whales in inshore Irish waters.
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Over the 20-year period (1999 and 2019) the Irish Whale and Dolphin Group recorded 92 individual humpback whales in Irish waters using photo-identification of tail flukes and dorsal fins, largely through citizen science. 80% of these individual whales were recorded more than once with 67% recorded over five times and 14% recorded over ten times. One individual has been recorded 48 times. A discovery curve is still increasing suggesting there are many more whales to capture from this population. Over one-half (55.4%) have been recorded in more than one year, with 9% recorded in five years or more and one in 13 of the 20 years of this study. The mean annual re-sighting rate ranged from 0-83% with a mean ± SD of 37.3±29.6%. The overall re-sighting rate of 55% is high showing great site fidelity. The number of re-

sightings of individual whales within a year ranged from 1 to 22 with a mean of 2.8. Residency times for individual whales were available for 143 occasions where two or more sightings were made within a year, and ranged between 2 and 168 days with a mean± SD of 38.8±37.3 days. The first whales were recorded in March and last in January. Residency time increased significantly with year ($P<0.05$). Most (89%) of all records were from Counties Cork and Kerry in the southwest. Mean residency in Kerry (35.5±35.9 days, n=52) was greater than in Cork (16.9±18.1 days, n=44) but was not significantly ($P<0.05$) and this longer residency likely reflects photo-id opportunities rather than any biological significance. Residency times on feeding grounds are often long providing they are obtaining sufficient food resources. Humpback whales in Ireland are thought to feed on sprat, herring and sand-eels and this study demonstrates the importance of Irish waters for a small but increasing humpback whale population.

Feeding in marine mammals: An integration of evolution and ecology through time.

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Key ecologic (e.g. competition, predator-prey changes), productivity (diatom diversity) and climatic (e.g. ^{18}O, ^{13}C) factors have driven patterns of marine mammal diversity through time. Based on a comprehensive diversity data set derived from the Paleobiology Database we considered feeding strategies (e.g., suction, biting, filter feeding and grazing), prey type (e.g. squid, fish, benthic invertebrates, zooplankton, tetrapods, sea grasses), tooth pattern and cusp shape (e.g. homodont, heterodont, pointed, rounded, or edentulous), and habitat (e.g. marine, riverine, estuarine) in fossil and extant marine mammals. These variables were then tested for correlation with each other and their changes through time examined in relation to productivity and climate variables. Among novel findings are that from an ancestry that involved a biting strategy with fish consumed, suction feeding of benthic invertebrates evolved as the principal prey capture strategy in the late Oligocene (cetaceans) and Pliocene (pinnipedimorphs). Bulk filter feeding in mysticetes became dominant beginning in the early Miocene. Sea otters arose during the late Pliocene feeding on hard-shelled benthic invertebrates, thereby filling a niche occupied during the late Miocene by the aquatic bear *Kolponomos*.

Examination of climate variables indicates that pinnipedimorphs are only correlated with diatom diversity (productivity) while cetaceans are correlated with diatom diversity and ^{18}O (temperature). Sirenians and desmostylians are correlated with neither ocean temperature nor productivity. Evidence for ecologic replacement among herbivores is indicated by the disappearance of desmostylians that coincided with appearance of the sirenian *Hydrodamalis* lineage in the North Pacific 11 Ma. Convergent evolution of herbivory in aquatic sloths was limited to the South Pacific during the late Miocene through Pliocene. Combined, these results show that many factors likely influenced marine mammal feeding diversity patterns in the past and a historical framework enables analysis of present day trophic structure and predictions of future changes in marine ecosystems.

Disturbance response of grey seals (Halichoerus grypus) to small Unmanned Aerial Vehicles (UAVs).

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The application of Unmanned Aerial Vehicles (UAVs) in the field of ecology is being increasingly recognised with a number of studies using different systems for collecting abundance, identification and measurement data for monitoring populations of marine mammals. However, there are few studies which have looked at the disturbance effects of UAVs on the animals they are surveying. The need for setting limits on UAV height and distance is needed for the management of the use of small UAVs for surveying marine mammals to ensure minimal or no disturbance is caused. Hauled-out seals are an excellent example where the use of UAVs can reduce costs of survey work and enable the survey of poorly accessible sites. This study aimed to test the disturbance effect of two UAV types, a fixed-wing and a quadcoptor, at varying heights above two colonies of grey seals (*Halichoerus grypus*) on the coast of Pembrokeshire, UK. An ethogram was created with six categories of behaviour from rest to flight, to enable observers to determine fine-scale levels of disturbance. Data was collected using focal follows and scan surveys to give a detailed picture of seal behaviour before during and after UAV flights. The fixed wing UAV caused no significant disturbance effect on the seals. The quadcoptor UAV enabled survey flights at much lower heights than the fixed-wing. Generalised Linear models were used to look at significant effects of type of UAV, and UAV height on the disturbance response of the seals. Results show no significant effect of

the fixed-wing UAV, but a significant effect of the quadcoptor on the disturbance response of the hauled-out seals. UAV height of the quadcoptor had a significant effect on the disturbance response of the seals, but seals only flushed when the quadcoptor was flown at 10m high.

Using multi-model ensemble forecasting to identify key feeding habitat for four cetacean species in Icelandic coastal waters

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Icelandic whales, dolphins and porpoises are under various anthropogenic pressures such as whaling, whale-watching and fishing activities in the region, and knowledge on their habitat preferences is lacking. The aims of this study were: 1) to investigate the functional ecological relationship between environmental variables (EGV's) and distribution of four cetacean species in Icelandic coastal waters, and 2) to predict areas (of seven bays located from south to northeast) of high suitability of these species and identity hotspots for spring (March-June) and autumn (July-October) months. We used an ensemble forecasting approach (BIOMOD) which has been shown to capture the distribution of species more accurately. Opportunistic sightings (2010-2014) of surface feeding humpback whale (*Megaptera novaeangliae*, *N*=156), white-beaked dolphin (*Lagenorhynchus albirostris*, *N*=123), common minke whale (*Balaenoptera acutorostrata*, *N*=436), and harbour porpoise (*Phocoena phocoena*, *N*=121) occurring on the SW (Faxaflói Bay off Reykjavik) and NE (Skjálfandi Bay off Húsavík) coasts was used. Seven EGV's were included in the models: depth, slope, SST, chlorophyll a concentration, aspect, tidal height, and shore distance. Models show that cetacean feeding distribution was better explained in the spring by aspect-chlorophyll and depth and in the autumn by aspect-chlorophyll and shore distance. Locations of suitable feeding humpback whales were mainly in northern coastal run-off areas in the spring and almost absent in the autumn. Minke whales were concentrated south in spring but show increased abundance at the northern coastal run-off areas in autumn. White-beaked dolphins were consistently found in deeper waters in both seasons while harbour porpoises were limited to deeper waters in southern bays. Predictions for the 7 bays reveal suitable habitat potential for all four species ranging from 22% (humpback whale) to 67% (white-beaked dolphin) of the total bay areas, highlights potential areas of conflict with human activities which should be considered for management and conservation.

Measurement of feeding-related dental microtexture using 3D surface texture analysis in Eastern Atlantic harbour seals (Phoca vitulina).

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Marine mammals are increasingly threatened in their habitat by various anthropogenic impacts. This is particularly evident in prey abundance. Understanding the dietary strategies of marine mammal populations can help predict implications for their future health status. The documentation of marine mammal diets therefore is essential for their conservation.

Dietary proxies might help in reconstructing dietary traits of marine mammals. In this study, we used 3D surface texture analysis (3DST, using 30 parameters according to ISO 25178) to quantify dental wear as an indicator of dietary behaviour. This method is an established approach to reconstructing diets in terrestrial mammals, but has not yet been applied to pinnipeds.

We analysed Eastern Atlantic harbour seals (*Phoca vitulina*) from the Baltic Sea (Hesselø, Denmark) and the North Sea (Wadden Sea, Germany), curated at natural history museums of northern Europe. Our aim was to 1) establish a workflow, opening 3DST to pinnipeds, 2) test 3DST for its ability in detecting dietary spectra of populations,

and 3) detect shifts in the dietary spectrum over the last 60 years.

A trend of increasing enamel texture roughness was found along the tooth row which should relate to prey processing biomechanics. The second to fourth postcanine tooth positions were established as a reference. We detect significantly rougher textures in the Baltic Sea population as compared to the North Sea populations. This signal is identified to reflect the deviation in prey species and thus suggests 3DST to be well suited to differentially infer ingesta composition in harbour seals.

Applying indirect dietary proxies, such as 3DST, thus will allow time series analyses of ingesta quality and prey availability using existing collection records. Furthermore, health status tracking over the last decades should be possible using collections. This approach will also help detect shifts in marine environments, both natural and anthropogenic.

Using emerging hot spot analysis of stranding records to inform conservation management

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Monitoring highly mobile species in relatively inaccessible habitats presents a considerable challenge to managers and policy makers. Effective conservation strategies require ecological knowledge that is often challenging and expensive to obtain. Despite their caveats, stranding data represent an underused resource to study the long-term dynamics of cetacean populations. We present a novel approach – emerging hot spot analysis (ArcMap 10.6.1) – to explore how stranding records can inform conservation management. While emerging hot spot analysis has been used to investigate malaria outbreaks, fatal landslides, and forest loss, it has not yet been applied to cetacean strandings. Using long-finned pilot whale (LFPW; *Globicephala melas edwardii*) stranding records from New Zealand as a case study, we demonstrate how emerging hot spot analysis can provide crucial insights into both the ecology and management of frequently stranded species. A total of 8,571 LFPWs stranded on the New Zealand coast within a 40-year period between January 1978 and December 2017. Strandings occurred in all months, though significant seasonal variation was evident, with 66% (n=189) of stranding events reported during austral spring and summer months (October – February). Hot spot analysis identified the majority of LFPWs stranded at Golden Bay, Great Barrier Island, Stewart Island and the Chatham Islands, with emerging hot spot analysis used to identify spatiotemporal trends. While no significant trend in the overall number of stranded LFPWs was evident, the number of stranded individuals has declined in areas of the Far North, Coromandel, Canterbury, Otago and the Chatham Islands, but increased in Golden Bay and Stewart Island. Such trends help identify significant clusters of stranding events and provide valuable ecological data that can be used to guide conservation management.

Companionship between female Grey Seals (Halichoerus grypus) on their breeding sites.

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There has been a significant rise in the grey seal population in the Netherlands since 2000s . While grey seals are considered solitary animals during most of the year, they are also known as colonial breeders. During the breeding season the species exhibits natal philopatry and site fidelity, which results in aggregations of the same individual females for many successive years. However, past studies have suggested that the association between female grey seals may not only be determined by habitat preferences, but might also be the result of sociality. This study aimed to gain insight in the social behaviour of female grey seals during the breeding season. The study was carried out on the uninhabited island Griend, located in the Dutch Wadden Sea, which has seen large morphological changes, both natural and human-induced. In this period the total amount of breeding females was ~60 . Photographs of females during the breeding season (from 2013-2018) were processed using the photo-id programme ExtractCompare, which recognises each individual animal by reading the

fur pattern of the neck, head or the flank. MapSource was used to estimate the GPS locations of the individuals. The between-year movement of each individual relative to their geographical location and that of neighbouring individuals in preceding years (5 year period) was estimated, to determine the strength of site-fidelity and companionship. Understanding sociality in temporarily aggregating species can contribute significantly to socioecological models of social evolution' .The study showed individual animals change their locations from the original spot between years. Any prominent companionship was not seen between the individuals over years.

Contrasting population-genetic structures in the Saimaa ringed seal (Pusa hispida saimensis) and its specialist helminth parasite Corynosoma magdaleni

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The Saimaa ringed seal (*Pusa hispida saimensis*) is one of the few pinniped species living in a freshwater environment and is exclusive to Lake Saimaa, Finland. The endangered population of approximately 400 individuals shows spatial genetic sub-structuring, potentially due to the high fragmentation of its lacustrine habitat. To further investigate the spatial genetic structure of the Saimaa ringed seal, we studied the population-genetic composition of one of its specialist endoparasites, the acanthocephalan helminth worm *Corynosoma magdaleni*.

We sequenced the standard 655-bp DNA "barcode" fragment of the mitochondrial COI gene from 176 worms collected from 25 seals. We identified 49 variable sites, representing 40 different haplotypes. Despite the high haplotype diversity, genetic structuring in the *C. magdaleni* samples was not explained by water basin, seal individual or seal intestinal section, and no pattern of isolation by distance was found.

We propose two explanations for the contrasting levels of spatial genetic differentiation in the Saimaa ringed seal and its helminth parasite *C. magdaleni*. First, in addition to the Saimaa ringed seal, the life cycle of *C. magdaleni* requires two intermediate hosts—a crustacean and a fish species—that could act as additional vectors of dispersal. Second, the sub-structuring of the seal population may be attributed to its small effective population size and its severe demographic fluctuations, while the effective population size in *C. magdaleni* could be much larger, as each seal may present tens or hundreds of worms. Further investigation using nuclear markers would enable to clarify this matter.

Guess who's coming to dinner. Dwarf minke whales along the Antarctic Peninsula: Evidence of climate migration or historic misidentification?

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The global distribution of dwarf minke whales (*Balaenoptera acutorostra subspecies*) is poorly understood, but it appears they tend to occupy low latitude waters off the coasts of Brazil, South Africa, and Australia, and have occasionally been observed in the South Indian Ocean. In March 2019, we encountered dwarf minke whales (n = 5) in the coastal waters of the South Shetland Islands (SSI), identified post-encounter through unoccupied aerial system (UAS) photogrammetry and resulting morphological and phenotypical comparison between Antarctic minke whales measured similarly around the Western Antarctic Peninsula (WAP) (n = 50). The only published study documenting dwarf minke whales along the WAP and SSI includes 11 sightings from 2007-2010, suggesting they are rare and only recently encountered in this region. One possible explanation for the paucity of sightings in this region is a southward range expansion concurrent with regional warming and ecosystem forcing that has facilitated southward range expansions of other sub-Antarctic species. This hypothesis is supported by ongoing changes in the distribution and abundance of myctophid fishes, an important prey item of dwarf minke whales. Alternatively, they may have always been present along the WAP and SSI, but have been misidentified as Antarctic minke whales. While distinct from other cetaceans, Antarctic and dwarf minke whales are difficult to distinguish from one another, especially from boat-based surveys. UAS photogrammetry provides opportunity to view these animals in high-resolution to distinguish subtle differences in morphology and phenotype. This study quantifies

phenotypic differences between dwarf and Antarctic minke whales, and compares them to other Southern Hemisphere populations, setting a foundation to effectively test hypotheses related to southward range expansions or historic misidentification. However, to address these competing hypotheses, comprehensive monitoring of minke whale encounters with high-resolution UAS imagery should be combined with biologging foraging studies, biochemical diet analyses, and prey field assessments.

Ideal flight parameters for the integration of Unmanned Aerial Vehicles in traditional cetacean surveys.

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The transition towards unmanned aerial vehicles (UAVs) in cetacean surveys and the subsequent shift to the automated collection and analysis of footage have enhanced our wildlife research capacity. Considerable advantages over traditional manned platforms include reduced costs, decreased noise and pollutant emissions, improved sighting accuracy and counting precision, etc. However, the short observation window provided by the UAV as well as the subject animals' behaviour (e.g., diving asynchrony) may result in an underestimated group or population size. Presented in this study is a new approach to determine the ideal coverage-to-resolution ratio for two cetacean species and the accuracy of group size estimates obtained from UAVs. The methodology includes survey passes at altitudes of 60-100 m and a speed of 33 km/hr, with a 70% front overlap between images; focal follows of each observed group for a minimum of 5 min provide for post hoc comparison with counts from survey passes. Fieldwork is carried out in the Mediterranean shelf waters of Israel, recently qualified by the IUCN as an important marine mammal area (IMMA) for the common short-beaked and bottlenose dolphins (*Delphinus delphis* and *Tursiops truncatus*, respectively). The challenging selection of small-bodied, fast-moving species which form large groups in this area was aimed to provide for maximal robustness and protocol standardisation across research groups and monitoring programmes employing UAVs.

Effective population sizes and modeling future genetic variation in the endangered Australian sea lion.

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Knowledge of genetic variation in the endemic and endangered Australian sea lion (*Neophoca cinerea*) is needed to evaluate inbreeding risk and resilience towards ongoing and future threats. The rate at which genetic variation is lost *via* drift is a function of the effective population size (N_e). We used 2238 genome-wide neutral single nucleotide polymorphisms (SNPs) from 81 Australian sea lion samples to estimate the N_e for two genetically distinct populations, one off South Australia (SA), and one off the west coast of Australia (WA). We used a linkage disequilibrium method to estimate N_e and applied adjustments for overlapping generations, life history parameters and chromosome number to derive an adjusted N_e of 424 (CI=397-458) for SA and 160 (CI=146-178) for WA. With stable population sizes and current observed heterozygosity (H_o) of 0.21(±0.004) for SA and 0.09(±0.003) for WA, modeling resulted in relatively small losses of genetic variation over 20 generations. Population declines are however ongoing. Including relatively conservative estimates of future population declines of 1.5% reduction/year resulted in a marked loss of genetic variation and increase in homozygosity, thereby increasing the risk of inbreeding depression. After modeling 20 generations H_o declined by 33% in SA, and 47% in WA. Incorporating population declines of proportions observed following disease epidemics in other pinnipeds resulted in higher losses of genetic variation. Models based on a single disease epidemic resulted in approximately half the genetic variation being lost within 20 generations (H_o=46%

for SA; and H_o=44% for WA). Small effective sizes and relatively low genetic variation leave the species vulnerable to future changes, and we show that that these risks are likely to be compounded if population declines are not reversed. Our results underscore the importance of safeguarding the Australian sea lion from future challenges, especially those that will greatly exacerbate losses of genetic variation.

Exploring Taiwanese white dolphin conservation using a social-ecological systems analysis framework: Process, achievements, and challenges.

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The social-ecological systems [SES] framework was proposed by Ostrom (2007). It is an integrated analysis structure serving as a unitary, holistic framework for researchers coming from different disciplines and who may be in different geographic regions, resource sectors, and biological, physical, socio-economic-political conditions. This framework facilitates incorporation of empirical research results by natural resource managers and policy makers, as well as their analysis of the process, results, and needed improvements in their work on conservation and sustainable development. In 2007 a group of Taiwanese conservation groups formed the "Matsu's Fish Conservation Alliance" for the purpose of conserving the highly endangered Taiwanese white dolphin (*Sousa chinensis taiwanensis*) and its habitat. The alliance's actions have focused on mitigating five major threats to the TWD, efforts that have included *inter alia*: forging alliances between religious and conservation groups; successful lobbying for the establishment of a new government Ocean Conservation Agency; promoting enactment and amendment of Water Pollution Act, Marine Coast Act and Wetlands Act; and stopping major industrial developments involving large scale land reclamation in TWD habitat. This research incorporates the SES framework in analyzing conservation action and governance process, achievements to date, as well as recommendations for improvements to conservation work based on this analysis.

The effects of seasonal variation, El Niño-Southern Oscillation events, and climate change on the tuna-dolphin association in the eastern tropical Pacific Ocean.

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Tuna and dolphins swim together in the waters of the eastern tropical Pacific, and this association has long benefitted tuna fishermen and intrigued scientists. Much is known about the association. Yellowfin tuna (*Thunnus albacares*) are primarily caught with spotted dolphins (*Stenella attenuata*), and, to a lesser extent, spinner dolphins (*Stenella longirostris*); historically the spotted dolphin has borne the brunt of the bycatch mortality. We know the primary promoter of the tuna-dolphin association is the unique ETP oceanography: a shallow mixed layer, a thick oxygen minimum zone, and warm surface waters. We know that as the mixed layer deepens, the association begins to break down; first with spinner dolphins, then with spotted dolphins. Important ecological and management questions remain. What are the effects of season, El Niño Southern Oscillation (ENSO) cycles, and long-term climate change on the association? What will be the future effects on the association with the continued influence of climate change? And how will these changes affect the fishery and dolphin mortality?

We used the IATTC observer data from 1992-2015 for pure herds of spotted dolphins and spinner dolphins (n=482,557 sightings), the SODA oceanographic dataset (0.5°x0.5° resolution), GIS and species distribution models to investigate which oceanographic variables most influenced the association's distribution, and predictive models (R-based GAMs and Random Forest) to test our results. The mixed layer depth had the most influence on the distribution of the association, but SST, temperature at 25-m depth, and ENSO Index were also significant factors. The spatial distribution of the association expanded and contracted with season and ENSO events, overlaid on a long-term expansion caused by climate change. The conditions that promote the tuna-dolphin association are intensifying and the management implications are already apparent: sets on pure spinner dolphin herds have increased, and spinner dolphins have replaced spotted dolphins as the leading component.

A comparison of percent dorsal scar cover between populations of humpback whales (Megaptera novaeangliae) off California and the Western Antarctic Peninsula

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Humpback whale populations are found around the globe, each influenced by a variety of natural and anthropogenic factors, including direct interactions with humans that can result in injury or mortality. Scarring rates in whales have been studied using photo ID images of the fluke and caudal peduncle to estimate prevalence of entanglement and ship strikes within a population. The present study compares percent dorsal scar cover between two populations (California and Western Antarctic Peninsula) of humpback whales exposed to different levels of human activity, derived from Unoccupied Aircraft System (UAS) imagery collected during foraging seasons from 2017-2019. Specifically, we use a semiautomated GIS algorithm to quantify percent scar cover by using a combination of high and low pass filtering and Jenks classification to determine the threshold used to identify scars from the image. This system extracts the scars and calculates percent scar cover on the portion of the whales back that is visible and available for assessment. We found that the California population (mean = 6.88%) had significantly higher percent scar cover than the Western Antarctic Peninsula population (mean = 3.21%) ($t = 3.02$, $df = 49.01$, $p = 0.004$). Our results indicate that there are behavioral or environmental factors related to scarring that vary between these two populations. Future studies should include classification of scar type and cause to better understand what drives this difference. Our approach provides new information on scarring rates of these two populations and presents a novel method for assessing scar cover adaptable to other species.

Saving whales, one smartphone at a time: The development of the WhaleReport Alert System.
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Along Canada's west coast, marine transportation is an essential part of life, serving both Canadian import and export markets and supporting many coastal communities. These activities overlap with the habitat of at-risk cetaceans including a critically endangered population of killer whales. As a result, both industry and the conservation-sector are motivated to reduce vessel-associated impacts to these vulnerable cetacean populations. Here, we detail the development, testing and implementation of the WhaleReport Alert System (WRAS), a cetacean conservation tool that broadcasts pertinent details of whale presence to large commercial vessels in real time. Information on whale presence is obtained from sightings reported via a smartphone application to the B.C. Cetacean Sightings Network, a well-established citizen science project that collects cetacean sightings from a network of over 6,600 mariners and coastal citizens. Developed in partnership with local ports and a working group of marine industry professionals, the WRAS allows mariners to undertake mitigation measures in the vicinity of cetaceans – such as slowing down or diverting course – to reduce the risk of collision and disturbance. The WRAS project highlights how citizen science initiatives and collaboration between scientists and industry can effectively contribute to the conservation of vulnerable species.

New insights about the world's only known, predictable winter aggregation of dwarf minke whales (Balaenoptera acutorostrata subsp.) in the remote northern Great Barrier Reef (Australia) and their implications for sustainable swim-with-whales management.
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The world's only known predictable aggregation of dwarf minke whales occurs at a remote shelf-edge, northern Australian location in the austral

winter. It supports a long-standing, swim-with ecotourism industry involving live-aboard dive vessels under permits from the Great Barrier Reef Marine Park Authority, designed to achieve sustainably managed interactions. The Minke Whale Project has been studying this unique phenomenon for >25 years.

We analyse multiple lines of evidence about the environmental characteristics of the aggregation area, its pattern of temporal and spatial use by this whale population, the life history stages and behaviour of the interacting animals in order to explore the significance of this location and its potential importance for the whales. We now know that individuals migrate from here to the Sub-Antarctic and return. Many whales have been resighted over periods spanning >10 years, with some individuals resighted almost annually. Recent genetic evidence from sloughed-skin sampling has shown that this population is identical with the South-West Pacific dwarf minkes killed by Japanese Southern Ocean scientific whaling.

Annual fieldwork has been conducted during June-July since 1996. Photo-identification data from researchers is augmented by tens of thousands of timed and dated underwater images donated annually by hundreds of passengers and crew from the commercial dive-fleet, providing a rich citizen-science-based source of sightings information. Four years of complete seasonal censuses of all individual whales identified (>500 in 2006, 2007, 2017 & 2018) are compared and their resighting patterns analysed to show their spatial and temporal use of the area. Data on mean (<10 days) and maximum (38 days) residence times are presented and satellite tracking data from 26 whales are used to refine the aggregation area use patterns from 2013-15.

The reasons for this unique aggregation area are explored and the extent of protection for the population and this very special location are discussed.

Fjords of Plenty: Herring overwintering superabundance as a seasonally important and accessible resource for humpback whales and fisheries in Northern Norway.

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Superabundance of Norwegian Spring Spawning (NSS) herring overwintering in North Norwegian fjords in recent years have attracted large numbers of humpback whales, which probably utilize this resource to top up energy reserves prior to long-range migrations. We attempted to estimate the importance of these events to humpbacks, and assess the impact of whales and commercial fisheries on local herring biomass during the 2014-2016 winters. Monthly hydroacoustic surveys (using an EK60 scientific echosounder with 70 and 200 kHz transducers), combined with spatio-temporal point process modelling, were used to estimate herring biomass and distribution within a focal fjord system. Whales were tagged with high-resolution activity/GPS dataloggers, and feeding lunges were identified using specific patterns in swim speed and acceleration. 3D tracks were reconstructed to estimate position of lunges relative to estimated herring biomass, allowing us to estimate daily consumption rates. Robust Design Mark Recapture based on photo-ID was used to estimate local population size and residence time. Estimated herring consumption by whales was compared to commercial catch data and the acoustically derived biomass estimates. Results suggest that local herring biomass in focal fjords (99 km^2, mean depth: 100m) increases from October to a maximum of 1.5 million tonnes (equivalent to ~25% of the entire NSS herring spawning stock) in mid-December, before gradually declining towards February. Estimated individual consumption rate was 1.5 Tonnes per day, translating to a total seasonal consumption of 18,000 Tonnes for an estimated population size of ~400 and mean residence time of ~30 days. This represents roughly half of the 37,500 tonnes taken simultaneously by commercial fisheries, and 1,2% of the maximum observed herring biomass. The high estimated consumption rates strongly support the idea that these superabundance events are important, but transient, opportunities for predators. Our results also suggest that the high local concentration of commercial fisheries and whale foraging are

unlikely to negatively impact this seasonally superabundant resource.

What if...?: Population viability analysis of resident Bottlenose Dolphins (Tursiops truncatus) in the Shannon Estuary (Ireland) to help inform management.

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Photo-identification is used to monitor the resident bottlenose dolphins (*Tursiops truncatus*) in the Shannon Estuary SAC (Ireland) as part of EU obligations to ensure Favourable Conservation Status. In 2015 a discovery curve using IWDG data collected during 77 photo-identification surveys suggested all animals in the population were captured providing an abundance of 145, which resulted in a mark-recapture estimate of 136 ± 18.03, CV = 0.13 (95% CI = 125-202). Concurrent in 2015, the NPWS funded an abundance estimate as part of their long-term monitoring strategy, involving 12 transects. We compared catalogues to identify any individuals not included in the IWDG data; there were none. We used this maximum abundance estimate with new demographic parameters to run Population Viability Analyses using Vortex in order to explore population status under potential management scenarios. Sensitivity analysis revealed adult and juvenile female mortality was the most influential parameter, followed by lifespan and reproductive rates, indicating the importance of female reproduction for population growth and persistence. Standard models showed stable dynamics (r = -0.007) and null probability of extinction (PE = 0) after 50 years projection. Reducing lifespan from 50 to 30 years (pollution effects) led to a decline (r = -0.033, PE = 0). Similar results were obtained when annual adult mortality increased from 3.8% to 7% (r = -0.032, PE = 0) due to by-catch. A single catastrophic scenario (oil spill) reducing survival and reproduction rates led to remarkable decline (r = -0.046, PE = 0.152). These results help managers to understand the implications of activities that may affect this small, genetically discrete bottlenose dolphin population. Current monitoring strategy may be insufficient to gain a proper understanding of population dynamics and we recommend higher annual survey effort as well as research on those population parametres which may affect long-term abundance trends.

Association patterns over thirty years and four generations of Bigg's (Transient) killer whales in relation to predation on gray whale calves in Monterey Bay, California

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Bigg's (Transient) killer whales occur year-round in Monterey Bay, California, which is bisected by a submarine canyon. Gray whale cow/calf pairs must cross this canyon on their northward migration to Alaska from Mexico each spring, leaving the protection of shore which is advantageous to their predators. Killer whales periodically patrol the canyon in search of these calves. Over 30 years, we photo-identified 180 individual killer whales. Since 1992, we documented 81 predation events on gray whale calves, and identified the individual killer whales most involved in the attack. They primarily travel in core groups composed of matrilines: adult females with their offspring. As the daughters of matriarchs had their own offspring, they eventually separated from their mother's group and formed their own group. Males usually remained with their mothers for life, but in some cases the second son left for several years. If their mothers died, they usually travelled alone or joined up with other lone males. Twenty-eight matrilines were regularly sighted, which included four extended families. Usually 2-4 matrilines (range 1-10) were present during calf predations. In most attacks, a combination of 2-3 out of 5 key reproductively active females with offspring from different matrilines were intensely engaged in the attack, while others watched or participated to a lesser degree. In the last 10 years, there has been a shift in key females: now their daughters with offspring are most involved in attacks. Several original key females have died, and most adult males have died. Key females who have spent 20 plus years attacking calves could kill them within an hour, compared to younger key females with less experience that took several hours to kill calves. Cultural transmission is essential for passing on the necessary hunting techniques to new generations of whales.

Developing a health baseline for narwhals (Monodon monoceros) from the eastern Canadian Arctic

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Rapid climate change is occurring in the Arctic and is potentially troubling for ice-dependent marine mammals such as narwhal (Monodon monoceros), that are likely to be sensitive to changes in sea ice and the marine environment. Multiple anthropogenic stressors related to climate change may cause deleterious health effects for this species. Environmental toxins, industrial activities, harvest, loss of sea ice, disease, ice entrapments, predation, commercial shipping and competing fisheries all have the potential to negatively impact narwhal populations. Healthy wildlife contribute to ecosystem health, a productive economy, and food safety and security in the Arctic. As apex marine predators, narwhal are part of the resilience of the Arctic marine ecosystem, yet very little is known about individual and population health or how they may adapt to a changing environment. Due to severe weather, darkness in winter, marine environment, and an extensive species range, the study of Arctic cetaceans is challenging. Narwhal health data have been collected from 2004-2018 during the ice free season using a transdisciplinary scientific approach. Health indices (hematology, serum chemistry, selected pathogen serology) were collected and analysed from over 50 live free-ranging narwhals from the eastern Canadian Arctic gathered through physical exams and sample collection conducted during live handling events. To date, these narwhal appear naïve to Cetacean morbillivirus (CeMV) and Influenza, and have varying levels of exposure to Toxoplasma gondii and Brucella sp. With the assistance of Inuit collaborators, thorough necropsy examinations were carried out on thirteen traditionally harvested narwhals to investigate disease caused by pathogens, toxins and neoplasia. Findings of interest included aural and pulmonary parasitism, pulmonary, endocrine and intestinal neoplasia, sarcocystosis and other mild inflammatory changes in myocardium and skeletal muscle. These findings comprise the groundwork for a health baseline for narwhals against which future changes can be measured.

Individual-specific calls in east Greenland narwhals – another type of signature whistle?

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Individually distinctive vocal signatures, first described in bottlenose dolphins about 50 years ago, have more recently been suspected in several other odontocetes, including the narwhal's closest relative, the beluga. During the summers of 2013-2018, we instrumented narwhals from Scoresby Sound, East Greenland, with acoustic sound and movement tags (Acousonde™). The records provided continuous information on the whales' acoustic behavior during diving, foraging, and social interactions, over periods of up to eight days. The calls in 12 complete records (four females, seven males, one of which was tagged two years in a row) were manually classified by human analysts. Each acoustic record included a distinctive call type that was stereotypical, was used by the tag carrier from a few times to >100 times over a few days, was sometimes repeated several times in succession, and was unique to the tag-bearer, i.e., the call was not heard in other records. These calls therefore share similarities with signature whistles described in bottlenose dolphins. "Signature calls" (SCs) in narwhals were burst pulses, sometimes augmented by other sounds such as whistles. In contrast to the deep diving during foraging (up to ~1000 m in Scoresby Sound), about 70% of SCs occurred in the top 50 m of the water column, where most social interactions are thought to take place. A subset of >120 SCs were analyzed in detail in terms of their pattern of successive inter-click intervals (ICIs). While overall length could be somewhat variable, the succession of ICIs was unique for each whale, and was maintained for the male tagged in two consecutive years. Anthropogenic activities are on the rise in the Arctic, leading to noise level increases. Therefore, conservation efforts will need to rely in part on understanding narwhal communication and social behavior – vocal signatures are a first step in that direction.

Costa del Sol: A harbour porpoise (Phocoena phocoena) habitat in the Mediterranean Sea. A collaboration between OceanSea and CostaSol Cruceros.

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The Costa del Sol waters are part of the Alboran Sea, which was recently identified as an Important Area for Marine Mammals (IMMA) by the IUCN (International Union for the Conservation of Nature). Between 2015 and 2019 the association OceanSea and Avistamiento Costasol Cruceros conducted a study in these waters on cetacean and marine turtle ecology as part of a project aimed towards their conservation. The data were collected between Benalmadena and Fuengirola and are a mixture of opportunistic and transect sightings. This study with over 500 recorded sightings has determined the presence and area preference of 6 different protected species in the coastal waters off the Costa del Sol; namely the bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), fin whale (*Balaenoptera physalus*) and loggerhead turtle (*Caretta caretta*). This being said, the most important species identified was the harbour porpoise (*Phocoena phocoena*) as it is currently considered to be absent in the western Mediterranean Sea (reference). Sightings of this species have been recorded in the same area every year from 2016 to 2019. This recurring presence of the porpoise means that they are using this area on a temporary, potentially permanent, basis which is the first on scientific record in the western Mediterranean Sea. This study shows the importance of collaborations between scientists and whale watching companies and the usefulness of correctly recorded data.

Do polar bear ecotypes in the Barents Sea region have different energetic requirements?

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Barents Sea polar bears *(Ursus maritimus)* are currently facing rapid environmental changes with loss of sea ice and changes in the distribution of their prey. Two distinct ecotypes exist in this region. Coastal bears remain within the Svalbard Archipelago year-round, whereas offshore bears follow the marginal ice zone (MIZ). We explore energy needs for these two ecotypes and how environmental changes may influence their energy budgets. Offshore bears travel longer distances on land and at sea, at a higher speed, and have a higher activity rate compared to coastal bears. This translates into higher overall energy expenditure. Offshore bears undertake longer and more distant swimming trips to the MIZ in rough weather that make these excursions energetically costly. Both ecotypes show similar seasonal patterns of activity and movement consistent with their life history linked to sea ice phenology. Despite higher energy expenditure, the offshore ecotype seems currently to be a more profitable strategy compared to the coastal one as females are in better condition likely due to their specialized high caloric diet of seals. However, both ecotypes are currently under stress as their respective habitats change. Coastal bears are losing glacial ice, and the degree of habitat overlap with their main prey the ringed seal is decreasing. Offshore bears are following the MIZ further away from land increasing their travel costs between fragmented suitable hunting and denning habitats. In addition, offshore bears have higher levels of persistent organic pollutants (POP) due to higher proportion of marine and high-trophic level food items in their diet and higher concentrations of pollutants in they prey. The latter strategy will remain profitable as long as the density of seals is sufficient to cover offshore bears' increase in energy needs and that the POP load does not affect the bears' physiology negatively.

Decreasing population trend and reproductive output in bottlenose dolphins (Tursiops truncatus) from the Aeolian Archipelago, Italy.

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Understanding the factors influencing population trends and reproductive patterns in wild bottlenose dolphin (*Tursiops truncatus*) populations is of strong importance for their conservation. A thirteen-year (2005-2017) photo-identification study have revealed complex societies and adapting behaviour to local environmental and anthropogenic conditions for a resident bottlenose dolphins' population in the Aeolian Archipelago (Italy; Blasi et al. 2012, Blasi and Boitani 2014, Blasi et al. 2015, Leone et al. 2019). In this area, the inshore occurrence of these dolphins is mainly related to fishery activities and, as fish stocks are generally declining, individuals are increasingly competing with coastal artisanal fishing. The encounter rate of the dolphin groups was drastically decreasing during the last few years. Only 7 reproductive females and their 16 calves were photo-identified during 272 focal follows. The mean number of calves for female was very low (2.3 ± 1.1 SD), ranging from 0 to 4 during the study period. The mean interbirth interval was 3.5 ± 1.6

(SD) years ranging from 2 to 7 years but it was between 2-4 for 5 females. Calf mortality was high (12.5% by age 1 for 2 calves) and 2 calves also died within 5 years. The 69.2% of epidermal marks on different body regions of dolphins were associated with traumata and gunshot wounds and/or mutilations were also frequently found. As 95% of bottlenose dolphins in this geographic area are resident (40 of 42 photo-identified individuals) and the 29% of reproductive females have died at the end of this study, we underline urgent conservation actions for this endangered bottlenose dolphin population.

Respiration-coupled heart rate changes in common bottlenose dolphins (Tursiops truncatus)

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Respiratory sinus arrhythmia (RSA) describes fluctuations in heart rate (f_H) associated with breathing and is universally observed among vertebrates. In terrestrial mammals RSA is characterized by an increase in f_H during inspiration and a decrease during expiration. Marine mammals are known to exhibit respiration-coupled heart rate changes, but little has been done to understand the role of f_H and respiration coupling during resting and diving behaviors in fully aquatic, air-breathing taxa. Because marine mammals maintain comparatively lower respiratory frequencies (f_R) than terrestrial mammals and exhibit intermittent breathing rather than continuous breathing, it would be expected that respiration-coupled heart rate changes may be exaggerated in marine mammals. Likewise, mammals in a marine environment are more often oxygen-constrained and therefore a strong cardiorespiratory coupling may improve gas exchange and reduce cardiac work. Our aim was to quantify fluctuations in f_H in spontaneously breathing, resting common bottlenose dolphins (*Tursiops truncatus*) to determine the extent of f_H variation that may be attributable to respiration. We measured f_H for nine male dolphins resting at the surface using respirometry to record respiratory flow and end-expired O_2 and CO_2 concentrations while continuously recording the electrocardiogram waveform, from which instantaneous f_H (if_H) could be calculated. As expected, the maximum if_H above the mean (16.0 ± 6.2 bpm, n = 207 breaths) in breath-to-breath segments occurred closely following the start of a breath (5.5 ± 2.0 s), and the minimum if_H below the mean (16.7 ± 6.1 bpm) occurred shortly before the start of the next breath (6.7 ± 3.5 s). The strength of RSA scaled with f_R as: $RSA = 82.11\ f_R^{-0.58}$. These results suggest that, for all f_R's, respiration has a predictable and significant effect on f_H. We suggest the importance of respiration-coupled heart rate changes in understanding resting and, particularly, diving heart rates of marine mammals.

An affordable, hand-deployable, rope-less and acoustically silent mooring design for passive acoustic monitoring, TOSSIT.

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Passive Acoustic Monitoring (PAM) in the ocean has become a standard technique across the oceanographic community, and is used for biological, geological and meteorological questions.

Current applications of PAM technology are: marine mammal population density studies, measures of anthropogenic noise in the ocean, soundscape measurements on coral reef to assess biological activities, monitoring and prediction of underwater earthquakes and tsunamis, in addition to several other military application.

During recent years, a plethora of different low-cost PAM recorders have been developed and made PAM available across a much larger scientific community, including smaller organizations and NGO's. Due to depth restrictions (~500m) of low-cost recorders most installations are conducted from smaller vessels and deployed by divers or on mooring lines with surface expressions, and not with elaborate mooring deployments. This limits the use of such devices to diving depth or, if simple mooring lines with surface expression are used, reduces data quality due to mooring induced noise like strumming and pulling, especially in high-current coastal areas.

Here, we present a low-cost, low self-noise and hand-deployable mooring design that can be used on up to 500m water depth and released by hand from a RIB. The TOSSIT modular mooring system consists of a light and strong modular non-metallic frame that can fit a variety of sensors including PAM instruments, acoustic releases, additional power packages, and environmental parameter

sensors. The rope less design avoids any risk of entanglement and keeps the self-noise very low.

We present noise data comparison of three different deployments in 10-160m water depth with adjacent deployments on traditional mooring setups.

Bowhead whale acoustic occurrence and vocal behavior in central Fram Strait

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The Arctic Ocean provides critical habitat for various marine mammal species, including the endangered Spitsbergen bowhead whale (*Balaena mysticetus*) population. In the context of climate warming and sea-ice reduction causing rapid changes in the Arctic Ocean, understanding the spatio-temporal patterns in the distribution and acoustic behavior of marine mammals is crucial for developing effective conservation and management strategies. Passive acoustic data are collected at different recording sites in Fram Strait since 2012, contributing to the Arctic Observatory FRAM (**FR**ontiers in **A**rctic Marine **M**onitoring). Here, data recorded at 78°50 N, 0°E from July to November 2012 were analyzed for the daily acoustic presence of marine mammals. Bowhead whales were acoustically present only in October and November, which coincided with increasing sea-ice concentration within 50 km of the recording site. Downsweep song (three types) was present in October and November, while upsweep song (one type) was only present in October. Furthermore, automatic detection of bowhead whale hourly presence using the low-frequency detection and classification system (LFDCS) retrieved 85% of the manually annotated hours with bowhead whale acoustic presence (recall) at 73% precision, hence making LFDCS a promising tool to process large sets of (long-term) passive acoustic data. Besides bowhead whales, blue whales *(Balaenoptera musculus)* and fin whales (*B. physalus*) were acoustically present from July to October, sperm whales (*Physeter macrocephalus*) in July and September, narwhals *(Monodon monoceros*) in October and November, and harp seals (*Pagophilus groenlandicus)* were present during all recording months. Acoustic species interactions in terms of temporal and spectral overlap of biophonic (blue and fin whale vocalizations) and anthrophonic (airgun) signals were detected in the low-frequency (<100 Hz) spectrum. Our results emphasize the importance of Fram Strait as marine mammal habitat, possibly providing (summer) feeding opportunities for blue and fin whales and an overwintering ground for bowhead whales and narwhals.

Characterizing bycatch and depredation in northeast U.S. sink gillnet fisheries.

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Fishery interactions are a critical concern for marine mammal population and ecosystem health. Fishery bycatch is currently the primary cause of mortality for marine mammals globally. Focusing on issues surrounding bycatch and depredation will help maintain sustainable fisheries and practices while addressing the impacts of conservation and management measures. We are using several methods to document interactions between gillnets and marine life, including underwater video cameras mounted on fishing gear, and on-deck documentation of depredation using scoring methods previously developed to identify predators of depredated catch. We are also documenting depredation using traditional hard-part analysis and prey DNA sequencing analysis of stomach contents from bycaught seals. Our objectives are to provide scientific support to commercial fishermen to allow for scientific ground-truthing of anecdotal evidence of depredation events. At the end of this project we will hold a forum to support community engagement and share details of findings and discuss mitigation methods based on findings. Through this approach, our overall objective is to build collaboration, trust, and community among local fishermen, researchers, and managers including documenting bycatch of marine mammals; and provide a platform for scientific research using commercial fishing operations. To date, we have obtained the first video footage of sink gillnet actively fishing in the northeast U.S., with documentation of depredation via this video analysis and from directly observed depredated catch. Preliminary results indicate that sub-adult gray seals (*Halichoerus grypus atlantica*) bycaught in gillnet were not engaged in

depredation of the net's target species at the time of capture. This was supported by prey DNA and hard part stomach content analysis. Ongoing video analysis is underway to quantify and characterize how and when these events takes place.

Deep diving cetaceans of the Mediterranean basin: The vessel survey component of the ACCOBAMS Survey Initiative (ASI), summer 2018.

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The ACCOBAMS Survey Initiative (ASI) is a major international collaborative effort to establish a coordinated regional monitoring system for cetaceans in the Mediterranean Sea. As part of the ASI, acoustic and/or visual vessel surveys were planned for those areas where aerial surveys could not be conducted in summer 2018. Equal spaced zigzag transects were designed and 21,829 km of track-lines were surveyed by R/V *Song of the Whale* in the western basin, Hellenic Trench and Libyan waters with a global acoustic coverage of 22% realised for sperm whales. R/V *CANA-CNRS* covered 1,055 km track-line off Lebanon, with Egyptian and Syrian coastal blocks to be surveyed during the summer 2019. As part of the vital capacity building aspects of the ASI, 30 participants from 10 countries across the region joined the team on *Song of the Whale* and four cruise leaders attended a vessel survey training course.

Nine species of cetacean were encountered including fin, sperm, Cuvier's beaked, long-finned pilot whales, Risso's, rough-toothed, bottlenose, common and striped dolphins. Turtle, fish and marine debris sightings were also logged. During the *Song of the Whale* surveys, towed hydrophone arrays were used to detect 152 groups of sperm whales and 18 groups of beaked whales (in small clusters of < 4 animals). Dolphins were detected throughout the survey, with group size decreasing towards the eastern areas of the western basin, and largest aggregations in the contiguous Atlantic waters. Ship, seismic and military noise were also documented. Abundance estimates from the vessel-based surveys will be presented.

The ASI vessel surveys provide substantial new datasets that can be compared with previous studies that have identified that the Mediterranean sperm whale subpopulation is alarmingly small. In addition, the ASI provides an update on the status of all cetaceans, establishing a baseline for future monitoring and conservation efforts.

Assessing the relationship between residency and population parameters in bottlenose dolphins off the southwestern Gulf of Mexico

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The presence of transient/temporary individuals in capture-mark-recapture studies may tamper the assumption on equal catchability, and thus yield biased estimates. We investigated for the first time the effects of individual residency in population parameters for bottlenose dolphins inhabiting the coastal waters off Alvarado, Veracruz, Mexico. We hypothesized that known sexual differences in access to the study area will result in lower recapture probability (C), (apparent) survival (Phi), and abundance (N) for male nonresident individuals. Between 2006-2010, we conducted 76 photo-id surveys and recorded 276 sightings, in which 235 dolphins were identified. A composite residency index (IH4) was computed for each dolphin, and transient individuals (recorded one time) were not included in the analyses. We split the sample (N=135 individuals) into three *a priori*-defined groups: residents (n=52), visitors (n=48) and temporary (n=35) via the *k*-means clustering method (k =3) using IH4 values. Population parameters were estimated for each group with the Cormack-Jolly-Seber model (C and Phi) and the Pollock´s Robust Design (N). There were 75 sexed individuals, including 60 putative females (residents 34, temporary 18, visitors 8) and 15 were putative males (residents 11, temporary 3, visitors 1). No difference was found in the expected proportion of sexes by residency degree (chi2 = 1.4, p=0.49, df=2). Significant differences amongst the median monthly C (H=43.6, p<0.001) were observed for all groups (residents 0.37±0.23, temporary 0.15±0.12 and visitors 0.09±0.11) supporting differences in habitat use, although unrelated to sex. Phi was 1.00 (± 0.00) for all groups, suggesting a similar impact by local

conditions on all groups. Finally, the median for N was only different (H=19.04, p<0.001) between visitors (16±15.4) and residents (48±6.5), being 33 (±16.2) for temporary individuals. These results highlight the importance of considering residency when dealing with failures in the goodness of fit because of heterogeneity in capture rates.

Perfusion requirements of the organs in large vs. small cetaceans.

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Perfusion of the viscera of the bottlenose dolphin (*Tursiops truncatus*) (and possibly other small cetaceans) is relatively like the human. Available information on the comparative weight of organs (brain, heart, lung, liver, spleen, stomach, kidney) or systems (skeleton and muscle) allow some speculations on the dynamics of blood circulation. Given the mass of a specimen, and the blood volume inside the body (7.4 % of the total body weight), the minimal specific perfusion flow rate for each organ can be calculated based on compari-sons with human or other small cetacean data. The dolphin brain is 0,8% of the total body mass and needs at least 50 ml/min of oxygenated blood for 100 g of tissue. Therefore, a 200 kg bottlenose dolphin whose brain weighs approx. 1.6 kg requires a minimal perfusion flow rate of 0.8 l/min (human: 0.75 l/min). However, correlations based on the said assumptions become hazardous with middle-sized cetaceans, and utterly im-possible with large whales including blue (*Balenoptera musculus*), humpback (*Megaptera novaeangliae*) and sperm whales (*Physeter macrocephalus*), and their like. The major changes are due to brain weight and blood volume, which are not increasing proportionally to body mass. Application of the encephalization quo-tient shows that the brain weight of the large blue whale is markedly inferior to what is expected for a mam-mal of such size (approximately 6.5 kg instead of 800 kg), and consequently the minimal perfusion flow rate remains well below the predicted 400 l/min. According to studies performed in whaling times, the weight of the blood in a sperm whale is only 3.9% of the whole mass. Here we investigate how the relationship be-tween vascularization and blood perfusion changes with the increase of body mass and the reduction of the expected brain weight in large whales, and the potential implications for diving.

Automatic detection of fin whale calls: Is available software good enough?

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Vocalizations studies are helpful to understand whale's ecology, population structure, distribution and links among individuals. Autonomous recording equipment generates vast amounts of data which in turn require a great effort for analysis. Although visual inspection is considered the gold standard, the time investment makes, in some cases, this option unfeasible and calls for autonomous detection methods. Software available is generally designed for specific taxa, but their use is often extended to other taxa without being properly evaluated. Moreover, when autonomous methods are used, detection rate is usually not specified in published literature. In this study three detection algorithms (Spectrogram correlation, bandwidth energy and energy sum) used in some of the most cited software (XBAT, PAMGUARD and Raven Pro) are compared to visual detection. Their sensibility and specificity within the context of fin whale (Balaenoptera physalus) call detection is presented. Audio files from an autonomous system deployed in the Gulf of California are used for this analysis. Field recordings include single pulses, call series, distorted signals, pulses of different intensity, noisy segments, and clear calls, so the algorithms are tested for real scenarios. In the best case only half of the signals were correctly detected. Since the fine tuning of the algorithms, parameter selection, and learning curve are also factors that contribute to the performance of the algorithms, they were also evaluated. PamGuard was considered the hardest to learn due to its modularity, followed by XBAT which is poorly documented, while Raven Pro was considered the friendliest environment. Parameter selection was most critical for XBAT: it presented the highest sensitivity values for all software tested upon a right selection, but sensitivity decreased to half with in other cases. Despite low sensitivity values obtained in this study, automated detection could still be useful in studies of marine mammal detection when sensibly used.

Long-term photo-identification of a data deficient species, the Indo-Pacific bottlenose

dolphin (Tursiops aduncus), reveals populations with distinct habitat use and social behavior in New Caledonia lagoons.

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Understanding the population structure and habitat use of poorly-known cetacean species is a first step towards scientifically informed management decisions. Due to their strictly coastal distribution and isolated populations, Indo-Pacific dolphins are particularly vulnerable to global changes and direct anthropogenic impacts. In New Caledonia (South Pacific), photo-identification and genetic data have revealed several distinct populations of this species around the main island, which precarious status and isolation are alarming. Here, we used a long-term dataset (20 years, 178 groups) to investigate the social structure and habitat use of Indo-Pacific bottlenose dolphins in the southern part of their New Caledonian range. A total of 928 individual observations were recorded, among which 310 unique individuals were photo-identified. Resighting histories revealed three distinct populations spread over a 100 km axis displaying variable levels of anthropogenic activities: the highly frequented southwest lagoon around Nouméa, the UNESCO world heritage site of the South Lagoon and the remote Isle of Pines. Individual home ranges computed with Kernel Density Estimates showed contrasting movements, from roaming (range: 32 km wide) to highly sedentary (range: 50 m wide). Among the latter, sedentary dolphins mostly confined to inner bays and isolated reef patches of the South Lagoon. Both at individual and populational levels, this diversity of habitat use patterns will be interpreted in relation to extrinsic factors (shark predation assessed from scarring) and intrinsic factors (cultural preferences assessed from social networks). Finally, anthropogenic threats will be comparatively assessed over the distinct populations in the southern waters of New Caledonia. Indeed, in a context of growing human impacts from maritime traffic, fishing and recreational activities, further investigation of collision and by-catch risks is warranted to evaluate the current conservation status of Indo-Pacific bottlenose dolphins in New Caledonia.

New Zealand sea lion pup behaviour around natural terrain traps and effectiveness of ramps for mitigation on Campbell Island

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New Zealand (NZ) sea lions (Phocarctos hookeri, NZSL), endemic to NZ, are currently listed as Endangered (IUCN Red List). Early pup (i.e. up to January) mortality, particularly on Campbell Island (Motu Ihupuku, the second largest breeding colony) is high (40 – 60%) where a considerable proportion of pups become trapped and die in natural mud holes/channels (hereafter terrain traps; TT). Previous mitigation efforts have included ramps to allow pups to self-rescue from the TTs. However, limited research has been done on Campbell Island due to its remoteness and there is uncertainty of the ramps' effectiveness in the long-term and their usage by pups. The aim of this project was to track movements of young pups in the breeding colony to assess how they are using the terrain and spatially quantify the risk of the TTs to pups. The study was conducted over 2-3 weeks in January 2018. We tracked the movements of pups (n = 20) using GPS trackers and placed remote camera traps around TTs. There was considerable movement of pups within the main colony and a 5m buffer zone of all TTs, indicating the TTs were in a highly used part of the colony and all pups are at risk of entering one. We found that when a pup was near a TT, there was a 14% chance of it entering the trap. However, this varied considerably among different TTs and the chances of falling into one increased when conditions were wet. Monitoring of pup behaviour in relation to TTs proved useful in better quantifying the impact of TTs on pup mortality vs other potential causes, e.g. extreme weather events, and the potential interaction between these. This information can guide appropriate mitigation options for known causes of mortality to reduce the overall high mortality observed at this site.

Augmenting fieldwork: Accessible deep learning for satellite-based whale detection.

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Many marine mammals, including most cetaceans, are wide-ranging and highly mobile, complicating efforts to collect reliable data at biologically-reasonable spatial and temporal scales. This has resulted in vast areas of ocean remaining never or rarely surveyed and has hampered our ability to describe habitat and population parameters. We used very high-resolution (sub-meter) satellite imagery and trained a convolutional neural network (CNN) to partially automate whale detection as a means to solve part of this problem. Our CNN was trained using down-scaled aerial imagery and tested on 31 cm-resolution imagery from the WorldView-3 sensor. The trained model correctly classified 100% of whales and 90% of image tiles that contained only water. This approach removes the need for tedious manual image classification and potentially opens up vast areas of the ocean that are infeasible to survey at sea. Moreover, it can augment existing field protocols to potentially improve temporal resolution and spatial extent. Such an approach can easily be adapted to different regions and iteratively improved as more whales are detected.

Developing a diagnostic tool to assess respiratory health in bottlenose dolphins (Tursiops truncatus) through spirometry

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Current methods to diagnose respiratory health in marine mammals do not provide information about functional changes associated with illness, which is often masked until the animal is severely affected. Our preliminary results suggest that spirometry is a useful, non-invasive method to diagnose lung health in dolphins and could be used to assess respiratory health in wild dolphins. Spirometry is used in human medicine and defines respiratory health by evaluating deviations from normal flow-volume (F-V) patterns. The present study was aimed to assess whether airflow limitations could be determined using F-V data in bottlenose dolphins (*Tursiops truncatus*) in managed care. Spirometry was performed through operant conditioning on 3 unrestrained dolphins (body mass: 196 ± 34 kg) resting in water each 6 months for one year. A pneumotachometer was placed over the blowhole and the dolphin instructed to perform 3-4 maximal expiratory efforts. The forced expiratory flow between 25% and 75% (FEF_{25-75}) of the forced vital capacity of each breath was determined. Lung health was validated through radiographs and standard clinical testing. One dolphin (D1) had chronic bronchitis while another dolphin (D2) developed pneumonia before the last testing date. The F-V loops showed a consistent shape between trials in the healthy dolphin (D3) with an average FEF_{25-75} of 35 ± 4 l · s^{-1}. A consistent F-V relationship was also seen in D2, but for the last trial with emerging pneumonia the F-V loop indicated airflow limitation at lower lung volumes, and the FEF_{25-75} decreased from 54 ± 2 to 30 ± 1 l · s^{-1}. The average FEF_{25-75} for D1 was 18 ± 1 l · s^{-1}, indicative of consistent airflow limitation during all testing periods. Consequently, our results suggest that spirometry is a diagnostic tool for cetacean lung health and helps improve knowledge of basic respiratory physiology.

Life in the fast lane: Foraging behavior of Antarctic fur seals (Arctocephalus gazella) at the edge of their southern most breeding distribution.

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At its most southerly breeding range, the Antarctic fur seal (AFS) operates at its highest field metabolic rate in an environment challenging the physiological limits for energy acquisition. Currently, we have little understanding on how edge colonies, already coping with high environmental variability, may deal with additional

variation contributed by specific atmospheric events. By using a combination of diet estimates and biologging we evaluated how additional environmental variability (2014/15 EL NINO year against regular years) may affect the behavior of these colonies. Foraging behavior was compared between all years using 18 variables that represent five categories: trip duration, recovery time (time ashore and surface time), diving effort, habitat use and diet. Differences were found in trip duration (longer trips), recovery time (shorter time ashore) and habitat use between 2014/15 and normal years. No differences were found in diving effort since colonies are already operating at their physiological maximum. Diet was no different between years but prey consumed changes throughout the breeding season from an specialist diet to generalist feeding behavior. This suggest that, in critical years, individuals will not take decisions that may risk the success of capturing prey (longer but close to shore trips and shorter time ashore) differing from other AFS colonies under critical conditions. Adaptive mechanisms may be shaping the behavior of these colonies highlighting the importance of research on evolutionary patterns in colonies living constantly in the fast lane of life.

Feeding ecology of the Ross Sea killer whale

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The fish-eating killer whale ecotype (C-type), also known as the Ross Sea killer whale (RSKW), is a top predator in the Ross Sea, Antarctica. It is mainly distributed along coastal areas, especially along dense pack ice. Knowledge about the diet of RSKW is scarce; it is not fully understood to which extent RSKW is dependent on Antarctic toothfish *(Dissostichus mawsoni*) which has been described as its primary prey species. Toothfish is also targeted from commercial fishery in the Ross Sea and this may have led to its decline and forced RSKW to compete with other predators for smaller and most abundant fish species such as Antarctic silverfish (*Pleurogramma antarcticum*). This might alter the foodweb delicate balance in the area. The aim of this study was to investigate the diet of RSKW by means of stable isotope analysis through a mixing model. Seven killer whales were skin biopsied, in Terra Nova Bay (Ross Sea) during austral summer 2015. Stable ratio isotopes of C and N were determined in the samples and a list of RSKW potential prey species in the area, with their stable isotope ratios, was compiled to run the model. The results suggested that diet of the sampled killer whales was mostly based on Antarctic toothfish, which represented about 35% of the biomass ingested, followed by Jonah's icefish (*Neopagetopsis ionah*) (33%) and by striped rockcod (*Trematomus hansoni*) (19%), while all other seven species identified, including Antarctic silverfish, showed less than 13% contribution to the diet. A better understanding of the trophic role of RSKW in the Antarctic food web represents a key research priority to inform management measures to be adopted in the Ross Sea Region Marine Protected Area as also recommended by CCAMLR.

An epigenetic clock for aging endangered cook inlet beluga whales

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A method for aging living whales and dolphins from biopsy samples could improve estimates of life history parameters and population viability. Until recently, however, estimates of age have relied on counting growth layers in teeth or ear plugs extracted from carcasses. Over the past decade, advances in mammalian genomics have revealed correlations between chronological age and DNA methylation, the addition of a methyl group to cytosines in cytosine-guanine di-nucleotide sequences (CpG sites). Our current research focuses on beluga whales (*Delphinapterus leucas*) from the Cook Inlet, Alaska, USA. Using a custom hybridization array developed from genes conserved across many mammal species, we have measured the methylation levels at over 30,000 CpG sites in the beluga whale genome. In parallel we have also implemented a candidate gene

approach to identify gene regions containing age-correlated CpG sites that can be used for targeted sequencing in future studies. Data from both methods reveal differential methylation at a subset of CpG sites that correlate with a calibration dataset of know-age individuals (n = 72). Using this relationship, we have built an initial 'epigenetic clock' for the endangered population of Cook Inlet beluga whales ($r = 0.9$, $p < 0.0001$, median age error ~2.8 years). Our methods and results contribute to the larger search for a solution to estimating the age of living whales.

Updating the assessment of southwestern Atlantic humpback whale population status

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Humpback whales from the population breeding in Brazilian waters were exploited by commercial whaling almost to the point of extinction in the mid-nineteenth century. The population increased once whaling ceased, but the historical carrying capacity is unknown; hence we do not know how close the population is to full recovery. We fitted a Bayesian population dynamics model to survey data and historical whaling records, and estimated carrying capacity (K), maximum population growth rate (r_{max}), maximum level of depletion ($Nmin/K$) and current level of depletion (N_{2019}/K). The model was based on a previously published study (Zerbini et al., 2011, J. Cet. Res. Man. Special Issue 3:131-144). Our goals were 1) to replicate the "base case scenario" presented in that study using a different fitting method (Markov chain Monte Carlo vs Sampling Importance Re-sampling), and 2) to update that model with newly-derived abundance estimates for 2008 and 2012 and information on rate of population increase. The base case was successfully reproduced. The updated model provided more precise estimates for population sizes and suggested that that carrying capacity and maximum level of depletion were lower than previously estimated (although posterior 95% credible intervals overlap those from the previous analysis). Results suggest the population will reach carrying capacity sooner than previously expected. We propose further developments of the model, such as using a more informative prior for maximum growth rate and less informative prior on carrying capacity to better capture scientific understanding of the system.

Escorting of mother-calf pairs of humpback whales (Megaptera novaeangliae) in the Gulf of Tribugá, northern Colombian Pacific, during the breeding season.

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Humpback whales (*Megaptera novaeangliae*) from the Breeding Stock G stock reproduce off the northwest coast of South America and southeast of Central America. The association between cows and escort(s) was examined with photo-identification and behavioral/spatial methods at the Gulf of Tribugá, northern Colombian Pacific, in 2010 and between 2013-2016. Groups were classified as mother-calf pair (Mc), mother, calf and escort groups (McE), and mother, calf, and multiple escorts groups (McME). Flukes and dorsal fins were used for individual identification. Positioned sightings were processed using ArcMap v10.3 along with public database layers (ERDAP y GADM) to calculate depth and distance to the coastline. Spatial variables were processed with a multivariate analysis. Chi-squared tests examined the presumed variation of surface behavioral frequencies among groups. A total of 108 groups with calves were encountered (22.4% of total). Despite obtaining fifteen re-sightings during the study period, there was no evidence of long-term association between cows and escorts. Additionally, four individuals identified as maternal escorts were also identified as members of competitive groups. Significant differences were found regarding the behavioral frequencies of unescorted vs. escorted mother-calf pairs. Mc pairs spent significantly more time resting and diving when compared with escorted pairs. On the contrary, McE and McME groups spent significantly more time traveling and executing surface-active and social/agonistic behaviors when compared with Mc pairs ($\chi^2_8 > 15.51$, $p < 0.05$). No significant differences when comparing depth and distance to the coastline data between groups $F(4, 208) = 0.564$ ($p > 0.05$). In conclusion, the association between cows and escorts appears to be transitory in the Gulf of Tribugá, occurs with no apparent spatial distribution pattern and, has a behavioral impact on Mc pairs, all consistent with a male mating strategy.

Geographic and individual-based differences in the trophic ecology of the Cape fur seal

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Information on resource use and trophic dynamics of marine top predators is important towards developing a holistic understanding of ecosystem structure and functioning. Where separate populations of conspecifics experience different local environmental conditions, geographic variability in niche use is expected. Individuals within populations may also vary in morphology, physiology and experience, resulting in individual-level differences and specialisation in resource use. In this context, isotopic compositions of incrementally grown tissues such as keratinous hairs offer valuable insights into individual-level variance in resource use. The Cape fur seal (*Arctocephalus pusillus pusillus*) is the only pinniped endemic to southern Africa. The breeding distribution of the species spans across a broad geographic range which is largely influenced by two contrasting oceanographic regimes, namely the Benguela and Agulhas currents. In this study, we investigated the trophic ecology of female Cape fur seals using isotopic signatures of serially sampled whiskers collected at four breeding sites along the coast of South Africa. Drawing on over 900 individual isotopic measurements, we assessed geographic variability in trophic niche width between colonies as well as the degree of individual specialisation. Individuals from colonies located within the Benguela current region exhibited higher δ15N compared to individuals elsewhere, while δ13C values were similar across the distributional range. Despite these marginal geographic differences, a large overlap in total trophic niche width between the four colonies was apparent. Indices of individual specialisation (WIC/TNW index) were generally low for both δ15N and δ13C. However, moderate levels of variation along the length of the whisker were observed for several individuals. Overall, our study suggests that while Cape fur seals are predominantly generalist foragers, within certain populations, specialisation at the individual level does occur. Results are further discussed with regard to individual foraging strategies, ecological opportunity and observed changes in prey availability.

Three-dimensional ecological niche of two endemic coastal dolphins from the Western South Atlantic

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The ecological niche of sympatric marine mammals has been studied through its proxy, the isotopic niche, in order to evaluate their degree of resource overlap and partition. Defining the ecological niche of species is important in order to understand their role within and ecosystem and to describe species-specific niche interactions. In this study, the ecological niche of two sympatric dolphin species that are endemic to coastal waters of the Western South Atlantic Ocean, the Lahille's bottlenose dolphin (*Tursiops truncatus gephyreus* n=22) and the franciscana dolphin (*Pontoporia blainvillei* n=12) was evaluated in order to characterize their resource use and overlap. We used $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ values in muscle of stranded specimens found along the Southern Brazil (31°21'S–33°04'S) to determine their niche region (95% probability region in the three-dimensional space) through the 'nicheROVER' package. We also estimated the probability of isotopic niche overlap (95% region) between species, defined as the probability that an individual from one species is found in the niche of the other species. Mean $\delta^{13}C$ and $\delta^{15}N$ in Lahille's bottlenose dolphins (-14.7±0.3‰ and 18.3±1.1‰) were higher than in franciscanas (-15.1±0.6‰ and 17.2±0.4‰) ($p<0.05$), while $\delta^{34}S$ values were similar (16.2±1.0‰ and 16.9±1.4‰, for bottlenose dolphins and franciscanas, respectively, $p=0.06$). The probability of niche overlap (mean [credible interval]) between those dolphin species was higher (57.65 [33-81]) in the case of the probability of a franciscana being found within the niche of the bottlenose dolphin than the latter being found inside the niche of the former (32.62 [18-53]). These preliminary results showed how these two sympatric dolphin species coexist by partitioning their spatial (e.g. $\delta^{13}C$ and $\delta^{34}S$) and trophic ($\delta^{15}N$) dimensions of their niche. Our results will help to understand the mechanisms that allow the coexistence of these endangered cetaceans and also predict changes in marine community structure.

Practical tools for assessing extrapolation in models of cetacean abundance.

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Density surface models (DSMs) are clearly established as a method of choice for the analysis of cetacean line transect survey data, and are increasingly used to inform risk assessments in remote marine areas subject to rising anthropogenic impacts (eg. the high seas). However, more and more DSMs are being applied well beyond the boundaries of the study regions where field sampling originally took place, leading to both uncertain and error-prone extrapolations that may mislead on-the-ground management interventions and undermine conservation decision-making. Building upon recent advances in extrapolation detection, we present a new R package for quantifying, summarising and visualising various forms of extrapolation within novel, multivariate environmental space. Although designed with traditional line transects in mind, the package is suitable for use with other data types, and optimised to be computationally fast on datasets of varying sizes. We illustrate our methods by revisiting previously published predictions of sperm whale (Physeter macrocephalus) and beaked whale (Ziphiidae spp.) abundance in the Northwest Atlantic, and evaluating them in light of several extrapolation metrics. We also use Monte Carlo simulations to demonstrate how ignoring extrapolation can lead to misguided management recommendations. Very early in their training, ecologists are warned against extrapolating, as model predictions made in data-deficient contexts rely heavily on assumptions that may not hold outside the range of sampled conditions. A transparent and consistent approach to identifying extrapolation is therefore a critical prerequisite to better understanding how models may behave outside the realm of values from which they are built, and knowing how much trust we can ultimately assign to their outputs. Our approach offers a user-friendly means of evaluating extrapolation a priori in order to guide model development and selection.

From seismic to science: Using passive acoustic monitoring data to enhance the knowledge of marine mammals off Brazil.

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Passive acoustic monitoring (PAM) has been implemented during seismic activities in Brazilian waters since 2012. Despite the growing amounts of PAM data being collected along the coast, information has been used mainly as a tool for mitigation purposes. Aiming to use the information for scientific studies, we analyzed PAM data collected during 3D seismic surveys carried out by CGG in the Espírito Santo and Campos basins between July 2017 and July 2018. Acoustical detections were made by Seiche PAM System, consisting of a linear array with two pairs of hydrophones placed 97 m apart, towed approximately 235 m behind and to one side of the seismic vessel. Monitoring effort was conducted 24 h a day and total number of acoustical detection events was 416 (> 191 hours), of which 120 (> 114 hrs) were mysticetes and 296 (> 77 hrs) were odontocetes. Raven Pro 1.5 was used for acoustical analyses focused primarily on the overall quality of sound recordings. Considering the signal-to-noise ratio, recordings were rated as excellent (n=24, 7%), good (n=143, 38%) and poor (n=207, 55%). Acoustic recordings were not available for 10% (n=42) of the detections. Excellent and good quality recordings were obtained for humpback whales, sperm whales, pantropical spotted dolphins and false killer whales. Although species identification through acoustic methods remains a challenge, it is achievable when animals are detected both visually and acoustically. Acoustic characteristics of oceanic cetaceans in South Atlantic waters are still poorly known and, in this regard, we are now measuring acoustic parameters of whistles and clicks from odontocetes and tonal sounds from mysticetes in order to characterize vocalizations of the identified species. We are confident that the results will help fill in the gaps in the knowledge of vocal behavior of marine mammals off Brazil.

The first assessment of social organisation of the Indian Ocean humpback dolphin (Sousa plumbea) along the south coast of South Africa.

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The Indian Ocean humpback dolphin (*Sousa plumbea*) is the most endangered marine mammal species in South Africa, and the overall decline of its abundance and group size may affect the social organization of the species, potentially accentuating its vulnerability. Understanding the social organization is therefore particularly relevant to conservation efforts. From photo-identification surveys along the south coast of South Africa from March 2014 to June 2015, we quantified association patterns and investigated the social organisation of humpback dolphins using the Half-Weight-Index, social cluster and network analyses. During the 101 surveys conducted and 553h of survey effort, 98 sightings of dolphins were recorded, and 65 individuals identified. Using individuals seen at least three times, this study reveals that the social network is well differentiated, as strong social divisions exist between individuals that seem to be split into four distinctive social clusters. Network strength was low; approximately half of the associations were low to moderate, while some individuals were strongly associated, especially between four pairs of individuals. Although this study is based on a limited number of individuals, our study nevertheless suggests that the atypical strong social bonds recorded here could result from behavioural responses following the decline in group size and abundance.

Abundance of ice-associated seals in the eastern Bering sea in spring of 2012 and 2013: A cause for concern?

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Ice-associated seals in the Arctic are likely to be vulnerable to long-term declines in sea ice and other effects of climate warming, but are difficult to monitor given their remoteness and expansive ranges. In 2012 and 2013, we used a combination of thermal imaging and digital photography to study the abundance and distribution of 4 species of seals (bearded seals, *Erignathus barbatus*; ribbon seals, *Histriophoca fasciata*; ringed seals, *Pusa* (or *Phoca*) *hispida*; and spotted seals, *Phoca largha*) from aircraft in the eastern (U.S.) Bering Sea. Applying species distribution models accounting for zero-inflation, overdispersion, incomplete detection, and species misclassification, we estimated that abundance and 95% confidence intervals of bearded, ribbon, and spotted seals were 275,443 (250,626-302,717); 56,485 (37,957-84,057); and 297,394 (249,721-354,169), respectively in 2012. In 2013, abundances were estimated as 247,218 (220,296-277,430); 39,476 (31,351-49,708); and 161,865 (140,310-186,732), respectively. We do not report on ringed seal abundance, which will require additional, specific analyses. Although we cannot rule out extreme differences in haul-out behavior from 2012 to 2013, the estimated 46% decline for spotted seals and 30% decline of ribbon seals is concerning. We note that the estimated decline coincided with an unusual mortality event associated with skin lesions and documented deaths of ice-associated seals in the Bering Sea and other Alaska waters between 2011 and 2014.

Repeatability and reproductive consequences of birth-site selection in grey seals (Halichoerus grypus).

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Selection of birth-site habitat can have important effects on the reproductive success of females and the survival of offspring. We studied birth-site habitat selection by grey seals (*Halichoerus grypus*) on Sable Island, Nova Scotia, and its consequences for body mass of pups at weaning. Birth-site habitat was determined in 584 known-age, females during the 2006 to 2016 breeding seasons. Over this period, these females produced 3,347 pups. We identified a mosaic of eight habitats using orthorectified imagery from a digital photographic aerial survey of the Island in January 2016. We then compared the distribution of birth sites in 2014-2016 with the available habitat in 2016. Vegetated dunes, beach under tidal influence and sandy areas inland of the beach accounted for 86% of the available habitat. Females selected beach and inland sandy habitats that were not floodable and avoided the same habitats were flooding occurred. Females also avoided vegetated dunes, hummocks and the heath community. Using longitudinal data for the entire study period and generalized linear mixed-effects models, we found that younger and inexperienced females pupped in different habitats than older and more experienced females. After accounting for maternal age, parity and pup sex, we found that pups born in inland sand habitat that did not flood averaged 1.5 kg heavier (3%) than those born on vegetated dunes or tidally influenced beaches. Although individual

females exhibited little evidence of site fidelity within the colony among years, they showed high repeatability in their selection of birth-site habitat. This along with boldness, birth date, lactation performance and milk composition suggest the selection for consistent individual differences is strong in this species.

Estimating seasonal movement and distribution patterns using animal tracking data: Application to Cook Inlet belugas.

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Cetaceans and other highly mobile species are often characterized by seasonal variation in movement and distribution patterns. The goal of this study was to estimate seasonal utilization densities for an endangered population of belugas (*Delphinapterus leucas*) in Cook Inlet (Alaska) using Argos telemetry data. A previous study using the same dataset described contrasting distribution patterns in June-November and December-May based on kernel densities of interpolated hourly positions. We used new analytical tools and methods (including the crawl() and ctmcmove() packages in *R* and a customized hidden Markov model) to extract more information on seasonal distribution patterns than was previously possible. We combined these tools to (a) estimate maximum likelihood locations of tracked animals after accounting for Argos measurement error and land barriers; (b) objectively partition tracks into seasonal modes; (c) estimate seasonal movement patterns as a function of environmental covariates; and (d) predict seasonally structured utilization densities. Analyzed tracks were characterized by three distinct seasonal modes: (i) summer/fall movements (e.g., June-December) restricted to coastal areas of northeastern upper Cook Inlet; (ii) fall-only movements (e.g., September-December) by some individuals, extending along the coastal areas of western Cook Inlet; and (iii) winter movements (e.g., November-March) expanding away from coastal areas throughout the upper Inlet and into the lower Inlet. The seasonally structured habitat selection patterns that emerge from this analysis provide new insights into the foraging ecology of Cook Inlet belugas, highlighting the importance of rivers mouths and bays of western Cook Inlet in fall. Understanding fine-scale habitat utilization of Cook Inlet belugas is important as this endangered population, with fewer than 250 mature individuals, is subject to increasing disturbance from activities such as construction, shipping, oil and gas development. Information on the belugas' seasonal distribution patterns could be used to minimize this disturbance and improve prospects for population recovery.

Estimating age and growth of West Greenland humpback whales through aspartic acid racemization and eye lens bomb radiocarbon methods

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Humpback whales of the North Atlantic were subject to an intense hunt for centuries and declined dramatically. In West Greenland, the population was estimated to constitute less than 200 individuals by the time the whaling moratorium was enforced. The years after with no hunt led to an increase in population size and an estimated annual rate of increase in West Greenland humpbacks was 9.4% yr^{-1} for the period 1984-2007 and a population size of 2,100 individuals by 2007. With the increase in numbers, followed a reopening of the subsistence hunt on humpback whales in West Greenland in 2010.

To decrease the risk of unsustainable harvest of marine mammals, there is a need to obtain knowledge on key life history parameters including age and derived attributes such as longevity, age at sexual maturity and age distribution within a population. The re-opening of hunt on west Greenland humpbacks offers a unique opportunity to sample individuals and gain knowledge on the biology and life history. Here, we use the eye lens from 12 humpback whales taken in the subsistence hunt to obtain age and growth estimates through aspartic acid racemization (AAR) and bomb radiocarbon dating combined. Furthermore, a Gompertz growth curve was fitted to the data.

Based on AAR, five individuals were between 0-9 years, six between 10-19 years and one was ~46 years. Radiocarbon dating showed that all individuals had elevated pMC values between 103 and 106 and therefore estimated to have been born

in the post-bomb period (i.e. after 1963), thus backing up the AAR ages. Whales reached their asymptotic length at approximately age 10.

The results indicate a young population of humpback whales following the many years of overexploitation. Also, radiocarbon dating in combination with AAR age estimation provides a valuable tool and steps towards age validation in difficult-to-age animals.

Deathly silent: Exploring the lack of peer-reviewed literature relating to euthanasia methods and efficacy.

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Euthanasia is key to minimising welfare concerns, yet is seldom straightforward. Safety as well as the need for trained personnel and specialist equipment are always essential considerations. Socio-economic, indigenous and/or religious beliefs can further influence decision-making. To understand current international best practice for marine mammal euthanasia, we examined the English language peer-reviewed literature to address (i) types of euthanasia applied and (ii) efficacy of methods. A total of 2,113 articles included marine mammals in the context of 'euthanize' or derivative words in either the title, abstract, keywords or text. A replica search for 'hunt' revealed a further 2,647 articles. Notably, only 3.2% (n=67) of the euthanasia literature detailed the actual method applied. Chemical euthanasia was most prolific (72%, n=48), followed by ballistics (13% n=9). Within the hunt search, only 2.7%, (n=71) of papers detailed methodology - the majority involving hand-held harpoons/spears (52%, n=37) or ballistics (45%, n=32). Most hunts reported using multiple techniques in unison. Efficacy of methods, determined by time to death (TTD), was detailed in very few euthanasia articles (0.5%, n=10), and even less in a hunt context (0.4%, n=11). TTD varied from instantaneous to 49.7h (mean=4.4h) and instantaneous to ca.3d (mean=7.1h) during euthanasia and hunting, respectively. Pinnipeds were the focus of euthanasia literature (53.7%, n=36), followed by delphinids (17.9%, n=12) and mysticetes (16.4%, n=11). In contrast, efficacy of euthanasia primarily focused on mysticetes (60%, n=6) and delphinids (20%, n=2). Similarly, most hunt studies involved pinnipeds (26.8%, n=19), followed by sirenians (21%, n=15). Whilst, efficacy of hunts focused on mysticetes (54.5%, n=6), with few pinnipeds (27%, n=3) reported. Our results highlight a disconcerting lack of scientific literature detailing marine mammal euthanasia, and an urgent need for comprehensive quantitative studies to address this void.

Excretion of Dehydroepiandrosterone Sulfate (DHEAS) in polar bears

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Polar bears (*Ursus maritimus*) are under threat due to climate change and habitat disruptions, and experience poor reproductive success in both wild and zoo settings. Polar bears are a seasonally polyestrous species that exhibit embryonic diapause and pseudopregnancy, complicating characterization of reproductive function. Whereas excretion of testosterone and progesterone has been studied extensively in female polar bears in zoos, many questions remain about their reproductive endocrinology. Dehydroepiandrosterone (DHEA) is a steroid hormone precursor that has been correlated with reproductive success, age, and body condition in other species. However, it has not been characterized in the polar bear. This study aims to validate a commercial enzyme immunoassay kit to quantify the sulfated form of DHEA, DHEAS, in dried polar bear feces to determine if there are differences in DHEAS concentrations between juveniles and adults in the breeding versus non-breeding season. Fecal samples were collected from juvenile (n = 4) and adult (n = 6) female polar bears housed in zoos. Steroids were extracted from 0.1g of lyophilized feces using 90% ethanol with overnight agitation. Four pooled samples representing juveniles and adults during the spring and fall seasons were tested for parallelism with the standard curve. A 1:10 to 1:160 range of serial dilutions produced a curve with a slope that fell within 10% of the commercial kit's standard curve for each group. Preliminary results suggest that adult females exhibit elevated DHEAS concentrations during the spring breeding season (mean: 923 ng/g, p value = 0.033) when compared to adult females in the fall (mean: 405 ng/g), or juveniles during either of the seasons (mean: 131 ng/g spring, mean: 324 ng/g fall) tested. This indicates that DHEAS may be a useful marker of sexual maturity in this species.

Assessment of online information as a tool to improve the documentation of aquatic wildmeat in Asia.

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Aquatic wildmeat is defined as products derived from aquatic mammals and reptiles that are used for bait, subsistence food and traditional uses. Aquatic wildmeat is obtained through unregulated, and sometimes illegal, hunts as well as from stranded and/or bycaught animals. Regular, high-volume take of multiple marine mammal species occurs in Asia, however, the vast coastlines of the region make monitoring efforts extremely challenging. Online media has become a valuable alternative source of data for terrestrial wildmeat but has never been explored for aquatic species. The objectives of this study were to assess if searching online information was a useful means to document aquatic wildmeat in Asia. Between 2015-17, searches of web platforms Baidu and Sina Weibo were conducted using various keywords. These searches identified 85 incidences between 2003 and 2017. These incidents involved 6 species of small cetacean (4 *Delphinidae* and 2 *Phocoenidae*). From these data, geographical areas were targeted for in person visits to fish markets, to ground truth online information. Further, interviews were also conducted in areas where there were no regular reporting. Shandong Province, China, was identified online as area where cetaceans commonly occurred in markets, especially finless porpoise (*Neophocaena* sp.). In general, online sources indicated only single animals were available, suggesting that catch was opportunistic rather than deliberate. Interviews in Shandong corroborated this. In contrast, in Vietnam where online accounts were relatively few, interviews indicated that marine mammal availability was relatively common. From the information extracted, species, the quantity of carcasses and intended use could be readily identified in 81.2%, 95.7% and 89.4% incidents, respectively. Further, relative trends in online media reflected trends published in systematic reviews of national strandings documents. In addition, online searches identified undocumented incidents. This study showed that online information, when carefully scrutinised, can improve the documentation of aquatic wildmeat in Asia.

Partial breeding migration of harbour seals in the southern North Sea

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Migration plays a central role in the spatial dynamics of many mobile species, though until now migration had not been demonstrated in the harbour seal (*Phoca vitulina*). In the Wadden Sea however, regional differences in pup production led to the hypothesis of an annual breeding migration. Seasonal migration of pregnant females between areas with low pup numbers (the Netherlands and Denmark) and high pup numbers (Germany) could explain the elevated pup production in Germany.

Between 2007 and 2016, 225 harbour seals were tracked using GPS data-loggers in the Dutch Wadden Sea. A total of 44 females were tracked during the breeding period. Based on movement and behaviour 27 females were identified as breeding. Twelve (44%) breeding females remained within 10 km of the catch site, but thirteen (48%) females migrated in an easterly direction towards Germany prior to the breeding season. Some feamales migrated 200 km to pup. After the breeding period most (78%) adult females moved in the opposite direction, (i.e. westerly), suggesting a return migration to the feeding grounds. These results suggest partial migration in this species. Migration distance varied significantly among individuals and may explain why such migrations have not been noticed previously. Further study of the movements of these highly individual animals may provide new insights in the population development and genetics.

Dams, Freshwater Flow and Climate Change: The future of the world's river dolphins

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Freshwater ecosystems host remarkable biodiversity including one third of all vertebrate species. Globally there are eight river systems, all in Asia and South America, that are inhabited by freshwater dolphins or porpoises. Every freshwater cetacean is listed as either Endangered or Critically Endangered on the IUCN Red List and it is these species that are likely to be at the forefront of the extinction crisis for marine mammals in the coming decades. Immediate threats to freshwater cetaceans are from high levels of pollution, fisheries bycatch, hunting, changing land-use and destruction of

forest in the river catchment, and construction of dams that change and deplete the natural river flow regime. In India and Pakistan water stress is so great that rivers are dammed and diverted such that they are barely flowing and dolphins have very little water to survive through the dry season. Predicted climate change related impacts on the large Himalayan river systems are linked to changing monsoon patterns, reduced rainfall, and depleted glaciers that will change river flow, and these changes will be exacerbated by increasing human populations and warmer air temperatures that will place even further demands on finite freshwater resources. Despite the concerns, in several cases, where a specific threat was identified and it could be removed, freshwater cetacean species have started to recover. For example, the Indus dolphin in Pakistan has been increasing in abundance since hunting was banned despite its severely fragmented habitat. The Mekong dolphin population is also increasing slowly since the removal of fishing nets from its core habitat. Some freshwater cetaceans have shown remarkable resilience in the face of overwhelming threat and this gives some hope that many may be able to persist despite the challenges.

Conservation of African manatee (Trichechus senegalensis. Link, 1795) in the SouthWestern Periphery of Campo Ma'an National Park. An ethno ecological and attitude survey.

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Of all sirenians, the African manatee (Trichechus senegalensis Link, 1795) is the least studied Species. The present study is a survey of ethno-ecology and attitude towards the species and is the first research on the African manatee along the coast of Campo Ma'an National Park, Cameroon.

It looks into the importance of understanding human attitudes associated with the manatee and its habitat in order to develop effective conservation strategies for the species and its habitat. During August 2015 to December 2016, a survey on manatee presence and distribution, as well as attitude and perception by local people was undertaken by conducting surveys both on land and water along the campo coast. The study area was stratified into ecological zones (coastal, river, estuary and mangrove). This allowed the survey of 99 fishers and 18 local authorities in six villages with landing ports using structured and semi-structured questionnaires. This work confirmed the presence of manatees in Campo. Institutions in charge of wildlife will gain much, as they do for other threatened species, if the population is sensitized to the conservation of manatees. Indigenous fishers consider the manatee as a deity, while foreign fishers consider this species as food and/or raw material for rituals. Manatee-fishers conflict is not very evident as compared to other areas were manatees also occur (Korup and Lake Ossa). However, fish marauding is the main cause of conflicts. Water survey conducted in three strategic points indicated the presence of the manatee (grazed vegetation, and floating faeces). It was reported that there has been a progressive reduction in the manatee population in recent years. Conclusively, this study has indicated that the manatee is still present in campo and fishers have a good understanding of this elusive species and its ecology.

Bottlenose dolphin (Tursiops truncatus) social structure and distribution changes following the 2008 unusual mortality event in the Indian River Lagoon, Florida

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In fission-fusion societies, environmental disturbances can influence the social and spatial structure of the population. Within the Indian River Lagoon (IRL), Florida, bottlenose dolphins (*Tursiops truncatus*) have experienced recurrent unusual mortality events (UMEs) providing an opportunity to examine post-disturbance restructuring within the same population. This study investigates the impact of the non-epidemiological 2008 unusual mortality event (UME) on the IRL dolphin population. Photo-identification surveys conducted from April 2006 to May 2010 were stratified into pre- (April 2006–April 2008) and post-UME (May 2008–May 2010) time periods. Analyses were limited to individuals sighted 6+ times (Pre-UME=163, Post-UME=138). Half-weight indices (HWIs) and network values were calculated via SOCPROGv2.8, while univariate kernel density estimates (KDEs) were calculated within ArcGISv10.4.1 and SASv9.4. Community associations were highly variable (Pre-UME range: mean=0.04±0.06–1.00±0.00; Post-UME range: mean=0.04±0.09–0.80±0.00), with a small subset of males (Pre-UME=6, Post-UME=10) who formed first-order alliances. Mean HWIs decreased between time periods (Pre-UME Md=0.02, Post-UME Md=0.01, U=9335, $p<0.05$), while mean non-zero HWIs increased (Pre-UME

Md = 0.12, Post-UME Md=0.15, U=5365.5, $p<0.05$) indicating fewer associations among individuals. Further, network analyses showed a decrease from 12 to 9 social communities in combination with increased community clustering post-UME (Pre-UME Md=0.05, Post-UME Md=0.07, U=7786, $p<0.05$). Univariate spatial analyses showed a disconnect between the northern Mosquito Lagoon communities and the rest of the IRL population during both time periods. However, there was no change in KDE overlap among communities following the UME (95%: Pre-UME Md=0.46, Post-UME Md=0.38, U=34, $p>0.05$: 50%: Pre-UME Md=0.19, Post-UME Md=0.14, U=49, $p>0.05$). These results illustrate the social resilience of IRL bottlenose dolphins to environmental and demographic changes despite impairment in adaptive immunity related to anthropogenic and natural stressors present within the estuary. Future studies on the effects of the larger, and more recent 2013-2015 UME will determine if this population continues to be resilient to multiple disturbances.

Prey abundance and habitat type are characteristics of 'hotspots' in the distribution of the endangered Hector's dolphin

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Marine species generally show hotspots in distribution, yet the habitat characteristics that underlie these features are unknown for many species, particularly at fine scales. Understanding what drives hotspots is important for identifying and protecting high quality habitat, and is thus vital for species and ecosystem management. Between 2015 and 2018, we conducted 187 systematic visual surveys for Hector's dolphins in nearshore habitat at Banks Peninsula, New Zealand, while simultaneously collecting a broad suite of data on the dolphins' habitat (including habitat type, bathymetry, oceanography and epipelagic prey). Surveys were carried out at four known hotspots in the dolphins' distribution and at six randomly selected 'reference areas'. Relationships between dolphin relative abundance and habitat characteristics were modelled using generalised additive mixed models. The best model (54% deviance explained) for describing dolphin distribution included data on the coverage of mud and reef habitat types, depth, tidal current velocity, surface chlorophyll and salinity, and prey abundance. Among all biophysical characteristics, the relative abundance of epipelagic prey had the strongest influence on dolphin distribution. Hotspots had more shallow, sandy habitat with higher current velocity and prey abundance, compared to reference areas. Knowledge on the habitat types that support high density of dolphins and their prey provides valuable new insights into the ecology of this nearshore ecosystem. Further, identifying the importance of these environmental features allows for management of habitat related threats to this endangered species.

Changes in gray whale foraging occurrence in the eastern Chukchi Sea, 2009-2018.

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Foraging gray whale (*Eschrichtius robustus*) occurrence in the eastern Chukchi Sea (67°-72°N, 154°-169°W) increased from 2009 to 2018 based on visual data collected during annual line-transect aerial surveys conducted from July to October. These systematic surveys, part of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, have been conducted since 2009 to document marine mammal relative density, distribution, and behavior. The Chukchi Sea serves as important foraging grounds for the eastern North Pacific gray whale (ENPGW) and is the northernmost extent of their geographical range. Foraging gray whale sighting rates (# feeding gray whales per km flown) in the northeastern Chukchi Sea (> 69°N) were higher in 2018 than any previous year. Sighting rates here typically decline in September as gray whales begin migrating south; however, in 2018, September sighting rates were three times higher than in September of any previous year. Gray whale preferential foraging habitat also shifted geographically between 2009-2015 and 2016-2018 in the northeastern Chukchi Sea. In the southcentral Chukchi Sea (< 69°N), gray whales were observed feeding in dense aggregations in a benthic hotspot during most years from 2014 to 2018, when survey coverage included that area. In 2018, sighting rates in the benthic hotspot were high in July but lower in August to October,

compared to previous years. Gray whales may be depleting benthic prey in some previously preferred foraging areas and moving to other areas that may have less nutritional value. Understanding gray whale foraging habits and habitats in the Chukchi Sea are key to understanding the health of the ENPGW population.

Using Unmanned Aerial Vehicles (UAVs) to estimate availability and group size error for aerial surveys of coastal dolphins.

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The precision of marine mammal abundance estimates based on aerial surveys relies upon accurate estimates of availability (the probability of animals being visible for detection) and group size. Here, we present a novel method of using small, vessel-launched, multi-rotor UAVs to collect aerial video of coastal dolphins to estimate availability and group size error, applicable to surveys conducted from aerial platforms. We collected 20 hours of aerial video of the dive-surfacing behaviour of Australian humpback dolphins (*Sousa sahulensis*) off north-western Australia. Estimates of availability based on 60 focal follows of consistent group composition ranged between 0.22 and 0.88, with a mean availability of 0.48 (CV=0.04). Availability was higher for follows with calves (0.53, CV=0.05) than without (0.31, CV=0.10), and trended higher with increasing group size. There was a downward bias in group size estimation, with true group size typically one individual more than would have been estimated by a human observer during a standard aerial survey. The variability of availability estimates between follows highlights the potential for bias, and the need to sample across a variety of group compositions, behaviours and environmental conditions. Furthermore, we undertook truncation/resampling exercises on these data to investigate how availability estimates and resultant precision varied with the number and duration of follows, with results providing an indication of target sample sizes to minimise bias in future research. We show that UAVs can provide an effective and relatively inexpensive method of estimating availability for coastal dolphins, with several advantages over existing approaches, including a visual perspective which is representative of the visibility of the animals from the air. These humpback dolphin availability estimates are within the range of values obtained for other shallow-water delphinids, and directly inform a program of aerial surveys in the region.

A polyphasic approach to determine ecological and toxilogical consequences of a new and cryptic species of cyanobacteria (Komarekiella delphini-convector) recovered from bottlenose dolphin epidermis

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On January 15, 2015, an adult bottlenose dolphin (*Tursiops truncatus*) was found dead with a thick, epidermal mat in low salinity habitat. The animal was matched to the University of North Florida's St. Johns River dolphin photo-identification catalog as Makena, whom had a history of skin lesions. Toxin analyses of Makena's hepatic tissue revealed the presence of either cyanotoxin microcystin or nodularin, both of which are produced by cyanobacteria. The composition of the epidermal mat was then investigated to determine if any species within this mat could have been the source of toxins found within the hepatic tissue. A species of cyanobacteria was grown in culture from the epidermal mat. Preliminary morphologic investigations revealed that this species had major phenotypic plasticity, obscuring identification. Further genetic (*i.e.,* 16S-23S ITS, full genomics) analyses revealed that this was a new species of cyanobacteria. This new species was the second member of the newly described genus *Komarekiella*. *Komarekiella* is a sister-taxa to the microcystin-producing genus *Nostoc*, highlighting the potential of this species having the ability to synthesize microcystin. Two types of toxin analyses (ELISA and the MMPB technique) were conducted on both the original epidermal mat and subsequent cultures, producing conflicting and inconclusive results. The full genome was then sequenced, and novel genome mining processes were conducted to determine the biosynthetic

capabilities of this species. Results showed that this species is very biosynthetically active (48 unique biosynthetic clusters identified), though the function of most of the biosynthetic clusters were not defined due to lack of sequence similarity. Further genomic analyses will be conducted to determine if any of these biosynthetic clusters are related to the synthesis of microcystins.

Deep trouble: Investigation into an unprecedented number of beaked whale strandings, eastern Atlantic, July-October 2018.

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Between July and October 2018, 100 beaked whales were reported dead stranded in advanced stages of decomposition in countries bordering the NE Atlantic. The majority of cases (n=73) were *Ziphius cavirostris* strandings along the west and north coasts of Ireland (n=24) and the west of Scotland (n=49) in August and early September, with a smaller cluster of *Hyperoodon ampullatus (*n=8) reported in northern Scotland in October (other species or regions=19*)*.

At an individual country level this represented an unprecedented strandings incidence for these species, and together comprised the largest unusual mortality event of beaked whales recorded globally, with impact likely at a population level. *Ziphius cavirostris* are a deepwater species known to be highly susceptible to noise, in particular mid-frequency active sonar. Identification of potential aetiologies was however challenging, as carcases were in an advanced state of decomposition and logistics restricted detailed necropsy examination of several cases.

Here we present the multidisciplinary integrative approach taken to investigate this event and suggest its relevance and implementation to future cases of mortality events where standard investigative methods aren't possible. The following results were integrated to identify plausible source regions and aetiologies for mortality:

1. Health and pathological data derived from cases recovered for necropsy;

2. Species and sex identification using short mitochondrial DNA fragment analysis of sampled cases;

3. Drift simulations for potential carcase origins, incorporating modelled ocean surface currents with effect of prevailing wind;

4. Acoustic analysis of broadband static and towed acoustic arrays operational in the NE Atlantic contemporaneously with this UME.

Cases examined exhibited pathology not inconsistent with acoustic trauma, for example fat emboli in lung parenchyma. Drift models suggested a focal source in the Rockall Trough and Porcupine Bank west of Ireland in July 2018. This investigation highlights how a multidisciplinary, collaborative approach can reduce the uncertainty and data-gaps often intrinsic to atypical mass stranding events, particularly of cryptic species such as beaked whales.

Amazon river dolphin abundance at an area of high touristic interest and implications for its management

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The boto, *Inia geoffrensis*, was recently considered endangered and robust population information is required to guide effective management measures. In the lower Rio Negro, AM, Brazil, since 1998 a tourism interaction activity has been developing in which wild botos are habituated to remain close to tourists in the water, but no information on the impacts of this activity for the botos exists. Here we present the first population estimates of botos in this area and discuss the tourism impact. We surveyed 992km between

Manaus and Novo Airão municipalities (an area of 1.666km^2) in April and October 2016. Boat-based surveys were performed with double observer configuration. Data was analyzed with R software ('mrds' package), in a mark-recapture distance sampling (MRDS) model, with trial configuration and full Independence assumption. The biological removal potential (PBR) was calculated according to Wade (1998). The abundance was estimated as 2.666 botos (IC 95% 1.499 - 4.831, CV = 0,3) and PBR indicated an annual withdrawal limit of 16 botos. Hipothetising that interacting botos are withdrawn from their ecological functions, PBR can be used as a basis for monitoring the impact of this activity on botos population and this is the first index produced in this area. In the last five years, the estimated number of interacting animals remains at around 50-60 botos and the PBR indicates that for this time a withdrawal of 80 botos from the population would not cause population decline. Monitoring and inhibiting the increase in the number of interacting animals is an easy-to-use management measure. We conclude that the touristic activity with botos, if correctly managed, should not be considered a threath to this species at a populational level. Population monitoring to obtain accurate PBRs indexes and close inspection of this activity are relevant management measures for boto conservation in the region.

A photoidentification study reveals a sex-related skin mark pattern in bottlenose dolphins (Tursiops truncatus) interacting with artisanal fishery.

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Skin marks occur frequently in many cetacean species across the globe revealing a broad spectrum of causes, including social interactions, infectious diseases and injuries produced by anthropogenic factors. The current study used photo-id data from 2005–2014 to estimate the skin mark pattern on resident bottlenose dolphins (*Tursiops truncatus*) from the Aeolian Archipelago (Italy). Thirteen skin mark types were identified and their origin, prevalence and permanence time were examined. The pattern of skin marks was assessed for the abundance, richness, distribution and severity in six body regions and compared among age classes, sex and degree of dolphins' interaction with trammel nets (DIN). Our results showed higher prevalence, abundance, richness and distribution of skin marks in adults than in the younger age classes, with the exception of black marks and white ring lesions. The prevalence and abundance of skin marks were higher in males than females, with the exception of scratches and white patches. Moreover, gunshot wounds, mutilations and irregular dorsal fin edges were found only on adult males. Since males showed higher DIN than females and, in dolphins with higher DIN, skin marks were more abundant and frequently distributed in different body regions, the skin mark pattern in regard to DIN seems to be sex-related. The more severe marks were observed on adults, males and dolphins with higher DIN, namely skin disorder, tooth rake marks, small shallow indentations, deep indentations and mutilations. On the contrary, the severity of scratches, white patches and dark ring lesions was higher in females than males, but not significantly related to DIN and age of the individuals. Our results showed that photo-id data provide an efficient and cost-effective approach to document the occurrence of skin marks in free-ranging bottlenose dolphin populations, a critical step toward understanding the cause and supporting the conservation strategies.

Ringed, bearded, and spotted seal productivity in Alaska using harvest-based monitoring, 1960s–1980s and 2000–2018.

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Declines in sea ice are predicted to negatively affect ice associated seals (ringed, *Pusa hispida*, bearded, *Erignathus barbatus*, and spotted, *Phoca largha*), important to Alaska Natives for food and materials, by reducing their time to rest, pup, nurse, and molt on sea ice. Concurrent with declines in sea ice are predicted reductions in snow depth used by ringed seals to construct pupping lairs. This is expected to lower productivity and pup survival by providing less protection from weather and predators. Estimates of ice seal abundance cannot be used to detect population trends in Alaska; however, data from the subsistence harvest can be used as an index of population health and status. We compared seal productivity during the 2000s to the 1960s and 1970s, before sea ice decline. Pregnancy rate from 2010–2016 (2010s) was higher for bearded (99%) and spotted (97%) seals than the earlier periods, and although slightly lower

now for ringed seals has remained relatively high (80%). A decrease in annual pregnancy rate was detected for ringed seals during an Unusual Mortality Event (UME) in 2010 (63%) and 2011 (47%), however, it recovered to 80% by 2012. The average age of maturity for all three seal species was lower in the 2010s than the earlier periods; with ringed seals at 3.6 (vs. 4.6) years old, bearded at 2.8 (vs. 3.4), and spotted at 3.2 (vs. 3.6). Additionally, a high proportion of pups were harvested in the 2010s indicating that pups are being produced, weaned, and surviving to be harvested. As of 2016, we had not detected negative effects in ringed, bearded, or spotted seal reproduction as was predicted with declining sea ice, however, record low winter sea ice extent in the Bering Sea in 2017 and 2018 may affect productivity. Here we update our results through 2018.

Exploring the genetic basis of boldness in female grey seals.

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Researchers have begun paying increasing attention towards the study of behavioural variation within a population or species, and furthermore towards the study of animal personality. Personality, defined as inter-individual behavioural differences that are consistent across time or contexts,influences various evolutionary and ecological processes including life-history characteristics, interspecific interactions, and responses to changing environmental conditions and anthropogenic pressures.Unfortunately, many investigations of personality end prematurely at the descriptive stage without further exploring proximate mechanisms underlying the behavioural variation. We have previously described evidence of a personality signal in a free-ranging population of female grey seals (*Halichoerus grypus*) on Sable Island National Park Preserve in Nova Scotia, Canada. High repeatability estimates suggest that boldness may have an underlying genetic basis. As such, we are now using molecular genetic association methodologies to gain insight into processes shaping and maintaining variation in personality. With boldness scores for over 450 females, we aim to perform a genome-wide association study (GWAS) using thousands of single nucleotide polymorphism (SNP) markers to identify genomic regions contributing to the observed behavioural variation in the Sable Island population. In addition, we aim to use a candidate gene approach as a complementary analysis to the GWAS. We have sequenced five candidate genes (dopamine receptor D4, serotonin transporter, oxytocin receptor, and the melanocortin 1 and 5 receptors) that have previously been shown to influence various aspects of behaviour in passerine, non-human primates, and domesticated species. Our sequencing efforts led to the discovery of genetic polymorphisms in each gene (35 total SNPs), facilitating genotype-behaviour statistical association analyses. Results from our study will contribute knowledge of the genetic architecture underlying natural behavioural diversity, and in doing so, will provide a basis for investigating the rate and direction of selective forces driving population adaptation in marine mammals.

Blue, sei and humpback whale acoustically-inferred distribution in relation to oceanographic features in Northern Chilean Patagonia using gliders and fixed timeseries data

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Northern Chilean Patagonia (NCP) is an extensive estuarine system (S 41°35-46°35) and known feeding ground for blue (BW), sei and humpback whales. Understanding whale distribution in this dynamic and heterogeneous habitat is a challenge. We seek to determine the distribution of baleen whales in relation to oceanographic features in the Corcovado Gulf to better understand underlying drivers. This is the first study of whales and in situ oceanography over the meso-spatial scale in Chile, and the first glider-based survey of cetaceans in Latin America. Slocum gliders were deployed in April 2018, and April-May 2019. Gliders were equipped with a Digital Acoustic Monitoring instrument (DMON) to detect whales acoustically in near real time, and chlorophyll-a/turbidity and temperature/salinity sensors. A mooring was deployed January-December 2016 and since March 2018 including: a SM3M hydrophone, an Acoustic Doppler Current Profiler (ADCP), an Acoustic Zooplankton and Fish Profiler (AZFP), and chlorophyll-a and temperature/salinity sensors.

Stratified zooplankton samples to validate ADCP/AZFP data were collected (n=20); zooplankton (n=20) and fecal samples (n=12) were used to infer/determine prey of foraging whales. Backscatter/oceanographic data were analyzed using standard techniques; passive acoustic data were analyzed using the Low Frequency Detection and Classification System (LFDCS). Acoustically-inferred occurrence of BW (most commonly detected species), was associated with thermal fronts, and intermediate/oceanic water masses versus estuarine water. Clear diel variation in BW calls was found, which was associated with zooplankton diel migration. Synoptic variation over a 16-20-day period was also observed. Seasonally, we observed a 1-month lag between chlorophyll-a and zooplankton maxima in March, and peak BW calls in April. Patterns were less marked for sei and humpback whales. Blue and humpback whales appear to feed on euphausiids (*Euphausia vallentini*), while sei whales feed on lobster krill (*Munida gregaria*). We discuss the possible processes that drive spatial/temporal distribution of these species, and make conservation and management recommendations.

Living at the limit: Distribution of small cetacean along Abu Dhabi waters, Arabian Gulf, UAE.

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The Emirate of Abu Dhabi is strategically located within the Arabian Gulf in a combination of geographical, oceanographic and ecological conditions which enable the presence of a rich cetacean fauna. Although the preservation of suitable habitats is necessary, the persistence of cetacean species in Abu-Dhabi waters cannot occur without a better understanding of their distribution, demography and use of habitat. Here we report the distribution patterns and group dynamic of cetacean species as integral components of the information needed to manage human impacts on marine mammals in Abu Dhabi waters. Overall, 13 days were spent at sea in April 2017, totaling 107 hours and 1 145 km of boat-based observations. During this time there were 57 encounters with cetaceans (35 with Indo-pacific bottlenose dolphins, 14 with Indian Ocean humpback dolphins, and 8 with finless porpoises). During these encounters 268 Indo-pacific bottlenose dolphins, 92 Indian Ocean humpback dolphins, and 37 finless porpoises were observed. These surveys confirm Abu Dhabi waters as an important foraging habitat for all these cetacean species. Indeed, behavioural data confirm Abu Dhabi waters as a breeding/nursery zone for Indian Ocean humpback dolphins and Indo-pacific bottlenose dolphins. Although the Abu-Dhabi humpback dolphin population is considered one of the largest in the genus Sousa in the world, based on previous studies, the observed decline in presence of humpback dolphins could be cause of concern. A number of interacting factors may have played a role in this decline, ranging from natural fluctuations to the potential impact of human activities such as oil and gas exploration (including seismic surveying) in the Central region during the surveys period. Therefore, further surveys are needed to confirm if this decline is result of a short-term seasonal variation in presence or on the contrary, is due to a real decline in the occurrence of this endangered species.

Stranding records of marine mammals in Kuwait

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As attempts to survey the cetacean populations in the Arabian/Persian Gulf increased in recent years, so does the need to raise public awareness regarding these animals and their current state. While most cetaceans tend to avoid areas with high human activity, stranded carcasses tend to catch the public's eye, and at the same time provide scientists with valuable data such as the cause of death, the animal's dietary consumption, the amount of pollution it might have in it's system, and even the stress levels in a fresh sample. All these insights can better help us understand the reality these animals face and better equip experts to give more crucial advice to the authorities to better insure their future in these waters. Our aim here is to provide a recored of the stranding events that took place in Kuwait from 2013 to 2018, we do so by examining public records as well as personal documentation of stranding events. We were able to put together a recored of 16 Strandings spanning 6 years in Kuwait waters. Some of these records were published online in press releases while others were individual sightings personally documented, or reported from fishermen. Of these carcasses, 2 were identified as finless porpoises, one as a humpback dolphin and one bryde's whale. We were not able to identify the other 12 carcasses, apart from one clearly belonging to a baleen whale

due to its size and general morphological features. A good step to take from here is to get in contact with local fishermen and engage them in surveys to gather better information on stranding incidents as well as raise their awareness to better document these events to the best of their abilities, to ultimately serve as a good tool for population assessment.

Environmental drivers of grey seal (Halichoerus grypus) pupping phenology in the Irish Sea.

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The causes and consequences of phenological shifts resulting from climate change has become a major area of interest in recent years, across many ecosystems and geographic regions. In communities that are strongly regulated by top-down processes, climate change-driven shifts in predator distributions and dynamics are likely to have disproportionate effects on whole assemblages of species and ecosystem function. Here we focus on grey seals (*Halichoerus grypus*), as a well-studied example of the marine predators. They are an iconic focal group in their own right as well important indicators of the wider effects of climate change. Using multi-decade data sets from major pupping sites in the Irish Sea, we set out to quantify how changes in the timing and progression of the grey seal pupping season are dependent on climatic drivers. We developed a logistic population growth model and estimated shifts in the timing and speed of within-season pup accumulation. We tested hypotheses on local and regional scale environmental drivers of these changes. Sea surface temperature was found to influence pupping season timing, and local winds affected the length of the season. We explore differences in these findings between pupping sites and consider implications for marine spatial planning.

Photo-identification of the Mediterranean monk seal sub-population in the central Ionian Sea, Greece

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Since March 2018, a systematic monk seal photo-identification project was launched in the central Ionian Sea, Greece. From May onward, 8 important marine caves suitable for resting and reproduction which were identified in earlier studies (1985-2002) were equipped with infrared cameras, thereby strategically covering the entire area of study. The pictures were analyzed from July onward; the process is still ongoing. Morphological characteristics of the fur distinguishing animals in pup, juvenile, subadult/adult, adult male, as well as individual scars were used to identify the animals. Animals were classified as adults only if evidence of sexual maturity was recorded (female with pup or adult male fur). The gender was attributed only to those individuals where the ventral part was clearly visible (ventral patch for pups; nipples, penis opening for the other categories, or the typical coloration of adult males). In the pictures up to November 2018, we identified and catalogued 18 individual seals: 3 adult males, 1 adult female, 9 sub-adult/adult seals (6 identified as females), 1 juvenile and 4 pups (1 identified as a female, 2 as males). Gender was evident only in 13 cases. Several pictures seem not to relate to the 18 already photo-identified animals but more data are undoubtedly needed in order to fully identify the animals. Seals not fully identified yet were not included in our catalogue in order to avoid an over-estimation of the actual numbers. Nevertheless, this fact indicates that the monk seal sub-population in the study area is composed of more than 20 animals, at least confirming previous minimum estimates. These findings outline the relevance of the central Ionian Sea for the conservation of this endangered species. The analysis of new material will reveal additional information on the size and other relevant parameters of the sub-population in the Greek central Ionian Sea.

Developing non-invasive fecal biomarkers to monitor Florida manatee health

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Over the past decade, seven mass mortality events of the Florida manatee (*Trichechus manatus latirostris*) have been documented, resulting in the deaths of more than 1000 animals. One *unusual mortality event* (UME) of undetermined cause in the Indian River Lagoon (IRL) remains under investigation but appears to be related to dietary shifts following the drastic loss of seagrass. Although carcass necropsy is invaluable, there remains a need for a non-invasive tool to detect changes in the health of wild manatees at the population level to better inform management. We developed enzyme-immunoassays to monitor manatee health by measuring glucocorticoids (e.g., cortisol; adrenal stress hormone) and triiodothyronine (T_3; thyroid metabolic hormone) in feces collected during live health assessments (n = 90) and post-mortem investigations (n = 29). Cortisol and T_3 have profound influences on energy mobilization and metabolism and are particularly responsive to nutritional deficits and extreme temperature insults. We found that apparently healthy wild manatees had elevated fecal cortisol and T_3 during spring-summer likely related to heightened metabolic demands due to breeding activity and increased food availability. Adult males, who often pursue a single female in competitive breeding herds, showed the greatest metabolic activity during this time of year. Both fecal cortisol and T_3 levels were lower in winter, when food becomes scarcer and manatees possibly conserve their energy reserves. Interestingly, manatees with access to naturally-warmed artesian springs had reduced metabolic activity compared to manatees overwintering in secondary warm-water sites, such as powerplant outflows. Manatees with signs of cold-induced stress or manatees that died during the IRL UME showed significantly elevated thyroid activity in winter compared to healthy manatees. This non-invasive tool could be useful to enhance manatee health monitoring during environmental perturbations, which are increasing in frequency and often challenging to investigate.

Long-term trends in Steller sea lion abundance in the Commander Islands, Russia.

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Steller sea lions (SSL) breed and pup on the Commander Islands (CI) of Russia, at the westernmost edge of the Aleutian Island chain. The CI are adjacent to the area of the greatest decline of SSL in the United States (US), the Western Aleutian Islands. Management of SSLs and fisheries interactions/competition is contingent upon accurate trend analyses in the CI as well as the US. We used published data and our own surveys conducted since the late 1980s to analyze long-term SSL population trends on the CI. SSLs were abundant in the CI in the late 1700's and bred on the archipelago until the mid-1800's when overharvest almost led to extinction. The population recovered by the mid 1900's when non-pup abundance in winter was >10,000 and breeding was observed. In contrast to the decline of the species in the Aleutian Islands, non-pup abundance on the CI in the early 1980s fluctuated around 2,000 individuals while pup production grew steadily to 280 pups in 1998. The high non-pup abundance and a steady positive trend in pup production have been attributed to a 30 nm no-fishing conservation zone surrounding the CI since the late 1950s. However, in 2000 pup numbers abruptly decreased to 180 pups (-33.6%). Pup abundance increased slightly during the next five years but never recovered and the long-term trend was negative through 2018 (-1.9%/year). Non-pup abundance declined >70% in the late 1980s and early 1990s from over 2,000 to 544 individuals in 1994. Abundance has continued to decline, and the 2015 count was 490 non-pups (-6.2%/year). Our studies suggest that the current negative trend is due to poor reproduction rather than any other causes and it is more likely that current declines in SSL numbers are more related to global oceanic environment changes than any local human-related causes.

Fin whale (Balaenoptera physalus) acoustic presence off Elephant Island (South Shetland Islands) Antarctica

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Summertime visual observations suggest that the region around Elephant Island may serve as an important feeding area for fin whales. To explore its year-round relevance, passive acoustic recordings collected northwest of Elephant Island (61°0.88'S, 55°58.53'W) from January 2013 to February 2016 were analysed for seasonal and diel patterns of fin whale 20 Hz calls. Calls were detected year-round, although in some years calls were not present during all months. For all years, fin whale calls were consistently present from March to July for more than 90% of days per month. From August to January, percentage of days with calls varied between years, with presence exceeding 75% of days per month throughout 2014, whereas in 2015 calls were absent in October and November. In 2013, fin whale calling dropped in August and increased again towards October and November. Quantitative analyses of power spectral density for the 20-Hz and 89-Hz fin whale bands, showed that fin whale acoustic power in both frequency bands followed a Gaussian-like temporal pattern, increasing in late January, peaking during April-May and decreasing in late August for all years. A second shoulder peak in PSD seemed to occur during the second part of July showing strongest for the upper fin whale band, followed by a rapid decrease, after which SNR for both bands dropped to zero. Diel patterns in call activity were analysed for a 10-month subset of the data from 2013. Fluctuations in call rates did not follow a diel pattern nor correspond to local insolation.

The observed peaks in fin whale call activity correspond to the periods during which fin whale super groups have been observed visually in this region. Our year-round acoustic analysis indicates that the Elephant Island region likely carries an important role for fin whales throughout the entire year.

Remote sensing and mapping the habitat features important to the large whale assemblage off Vancouver Island.

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A key issue in cetacean research is understanding the effect of anthropogenic influences. However, basic knowledge of many of the large whales, including presence, number, and habitat use is lacking. We used ocean gliders to survey regions once described as productive whale habitat, and focus on the continental shelf break and areas of bathymetric relief, such as submarine canyons. Passive and active acoustic measures, as well as habitat variables such as conductivity and temperature, were collected to compare ocean and prey-scape features coincident whale presence.

Whale calls in the passive acoustic data is a proxy to presence. Use of the call repertoire guides our interpretation the whales' behaviour and area use. Tying habitat variables to this can further strengthen conclusions as well as outline important habitat areas over space and time.

Large baleen and toothed whales were located off the west coast of Vancouver Island, with most calls heard along the shelf break. We recorded blue, fin, humpback, sperm and possible sei whales, all of which were heavily targeted by whaling. Call type suggests the presence of feeding, socialising, and breeding/calving behaviours. Spatial analysis shows distinct zoning in horizontal and vertical space between on- and off-shelf and relief areas. The comparison of multiple deployments in the region allows comparison of winter to spring-like conditions, and the prey aggregations derived from upwelling. Creating surfaces from point data allows us to start to reconcile the spatial mismatch between the scale at which the habitat data is collected and the area over which whale calls are propagated. Establishing patterns in habitat variables helps predict the importance of these areas to a variety of large whales species, and the effect that human activities could have on their use.

Understanding diet, past and present: Insights into the foraging ecology of Falkland Islands Sei whales using DNA metabarcoding and stable isotope analysis.

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Despite being the third largest of the iconic baleen whales, little is known about the diet of the sei whale (*Balaenoptera borealis)* in the Southern Hemisphere. Here we provide the first assessment of sei whale diet using DNA metabarcoding and stable isotope analysis of both contemporary and historical material. Specifically, we analyse skin, faecal and bone samples collected during the austral summer of 2017 to 2018 alongside historical bone samples gathered from the start of the modern whaling era (~1910) from New Island whaling station, Falkland Islands. Bone collagen and its intrinsic isotopic values are stable over millennia and can be used to infer dietary preferences of historical populations. Ratios of stable isotopes found within contemporary tissues of varying turnover rates (e.g. skin vs. bone) can provide insight into foraging preferences over different temporal scales. DNA metabarcoding of scats can be used to taxonomically identify prey from recent foraging bouts. Our dataset permits three questions to be addressed: (1) what is the current diet of sei whales in the Falklands Islands? (2) are stable isotope analyses comparable over a multitude of tissue types and time periods? and (3) has diet changed since whaling occurred in this region? Our results from 35 contemporary and 12 historical samples suggest (1) a presence of fish and crustacea in modern sei whale diet as inferred using DNA analysis. We also find that (2) nitrogen isotope ratios do not differ between bone, blubber and skin tissue types, making it possible to compare trophic levels between historical bone samples and modern bone, skin or blubber samples; analyses of these suggest that (3) whaling has not impacted the trophic ecology of sei whales over the past century. Further results based on ~40 contemporary and ~40 historical samples are currently being analysed.

The role of sociality in the response of killer whales to an additive mortality event

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In highly social top-predators, group-living is an ecological strategy that enhances individual fitness, primarily through increased foraging success. Additive mortality events across multiple social groups in populations may affect the social structure, and therefore the fitness, of surviving individuals. We examined this hypothesis in a killer whale (*Orcinus orca*) population that experienced a 7-year period of severe additive mortality due to lethal interactions with illegal fishing vessels. Using both social and demographic analyses conducted on a unique long-term dataset encompassing periods before, during and after this event, we found a decrease of both the number and the mean strength of associations of surviving individuals during the additive mortality period. A positive significant correlation between association strength and apparent survival suggested that the fitness of surviving individuals was impacted by the additive mortality event. After this event, individuals responded to the loss of relatives in their social groups by associating with a greater number of other social groups, likely to maintain a functional group size that maximized their foraging success. However, these associations were loose; individuals did not re-associate in highly stable social groups, and their survival remained low years after the mortality event. Our findings demonstrate how the disruption of social structure in killer whales may lead to prolonged negative effects of demographic stress beyond an additive mortality event. More importantly, we show that sociality has a key role in the resilience of populations to human-induced mortality; this has major implications for the conservation of highly social and long-lived species.

Monitoring the population of the South American sea lion in southern Chile from 1998 to 2018: A methodology for population estimation at large-scale.

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The South American sea lion, *Otaria byronia*, has a wide distribution in South America. The species has an estimated abundance of about 500,000 individuals, 192,000 of which inhabit the Chilean Coast (between 17º30'S and 55º58'S): northern (95,000), central (28,000), and southern (67,000) Chile and Magallanes (2,000). The aim of this study is to analyze the population trend of *O. byronia* in the five main breeding colonies of southern Chile and to estimate the total population on a large scale. Aerial photographic surveys were conducted in Isla Doña Sebastiana, Isla Metalqui, Punta Chaiguaco, Isla Guafo and Isla Guamblin during the austral summers (1998, 2007, 2012, 2013, 2016 and 2018). The individuals in the colonies were counted and categorized in age classes by three independent observers. The overall abundance during the surveyed years was: 30,581±1,223; 32,155±1,286; 48,990±1,960; 55,585±509; 56,310±958 and 38,664±386 individuals, respectively. Isla Metalqui is the main breeding ground in Chile, with 56% of the population observed in these colonies during 2013 including 14,331±68 newborn pups. If we analyze the abundance of the five colonies during the years 1998, 2007 and 2012 (with available abundance data for the entire Chilean territory) we find that these colonies accounted for 90%,91%,90% and 41%,31%,34% of the total pups born in southern Chile and in the entire country, respectively. Moreover, 56%,64%,74% of the total population in southern Chile was concentrated in the five colonies in those years (from 139 colonies). A linear regression was the best-fitting model, which can be used in the future to predict the target species abundance (colonies vs. overall abundance, r=0.942). This methodological proposal contributes to the goal of obtaining a large-scale population estimate with a high level of certainty, reducing the costs of aerial surveys to provide scientific information for conservation, potential biological removal estimations (MMPA) and global protection measures.

Combining citizen science and automatic identification system to monitor marine mammals' distribution patterns

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Monitoring marine mammals' distribution is essential for marine spatial planning. However, systematic data acquisition is expensive, time-consuming and usually associated with trade-offs of sampling effort, spatial scale, and ecosystem representativeness. Citizen Science (CSci) has the advantage of valuing citizen participation and increasing the volume of data. Here, we illustrate the advantages of the combined use of CSci protocol and Automatic Identification System (AIS) data to the monitoring of large whales' occurrence and distribution patterns within the Saguenay–St. Lawrence Marine Park, QC, Canada. CSci data collection took place from 2012 (pilot study) to 2018 on board a whale watching boat with the participation of naturalist guides. Each time the whale watching boat reduced the speed to approach a targeted species, the sighting was reported with an approximate time. AIS data were stored throughout the season, and in order to maximize its use, an algorithm was developed to define the boat's activity (observation versus travelling/searching) based on its speed, which has been validated by a systematic and independent data set. Besides providing information on survey effort, the combined use of CSci-AIS allowed positioning the sightings, estimating the time spent in observation of each species over the season and mapping of the main observation areas. CSci provided almost daily information on the occurrence and distribution of Minke (*Balaenoptera acutorostrata*), Fin (*B. physalus*), Blue (*B. musculus*) and Humpback (*Megaptera novaeangliae*) whales. Since the beginning of the monitoring 1545 excursions were sampled on 790 days covering up to 93% of the whale watching season. More than 3000 sightings of these species were reported, from which 62% were located. CSci-AIS allows fine-scale and long-term spatial data collection at low cost, provides support for marine spatial planning and conservation efforts and, additionally, empower naturalist guides and engages whale watching companies in the monitoring of the targeted species.

Comparative genomics of Sotalia guianensis and Sotalia fluviatilis: Divergence and adaptation to a riverine environment.

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Dolphins belonging to the genus *Sotalia* are endemic to Central and South America and two species have been recognized: *Sotalia guianensis*, found in coastal environments along the Caribbean and the Atlantic as well as in Maracaibo Lake and the Orinoco River, and *Sotalia fluviatilis* is found in the Amazon River and in most of its tributaries. These dolphin species are an interesting model to study adaptation and evolutionary processes in marine and freshwater environments.

Previously, a comparative analysis of the mitochondrial genome provided evidence of positive selection, suggesting differences in their energy metabolism in each environment. In order to further investigate adaptive selection of the nuclear genome, we performed whole shotgun genome sequencing on two samples from each *Sotalia* species, using Illumina short read technology. We obtained an average 90,644,338 short reads (150 bp, paired-end) per sample. Genome assembling is currently underway using different platforms and algorithms (i.e Unicycler) and read mapping has been done with Bowtie2 on Galaxy against the recently published genome of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*), with an overall alignment rate of 94% for *Sotalia guianensis* and of 88% for *Sotalia fluviatilis* and also against the annotated genome of the Yangtze finless porpoises *Neophocaena asiaorientalis,* resulting on an overall alignment rate of 82% for *Sotalia guianensis* and of 84% for *Sotalia fluviatilis*. These results are preliminary, but additional analyses will allow evaluation of genomic regions related to convergent adaptation to freshwater environments in these species.

Urinary parameters of the Antillean manatee (Trichechus manatus manatus) in the Caribbean

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The urinalysis is an easy, rapid, inexpensive and non-invasive tool that allows the documentation of renal and systemic functioning through the increased or decreased elimination of certain metabolites. For this reason, urinalysis can help monitor the health status of manatees. However, there are no reference values for this analysis in Antillean manatees (*Trichechus manatus manatus*). The following work aimed to know the physical, chemical and microscopic characteristics of the urine of 23 manatees belonging to this manatee subspecies under human care in four Caribbean facilities. The samples were obtained through the implementation of operant conditioning; the analysis of the chemical and microscopic characteristics was carried out through the use of multiagent chemical test strips, pH reagent strips, refractrometer, and sediments were analyzed using a compound microscope. The physical characteristics found revealed that the urine of the Antillean manatees presents a straw yellow pigmentation with a clear appearance and a urinoid odor. The chemical test determined that glucose, bilirubin, ketones, proteins, blood, leukocyte and nitrites were negative and constant in all the samples analyzed. However, the urine was found to be alkaline with an average pH of 8.1 ± 0.80, and a low specific gravity of 1.010. Urinare sediment included, few squamous cells (78.3%), erythrocyte cylinders (8.3%), calcium oxalate crystals (26%), amorphous urates (4.3%), and triple phosphates (4.3%). Sperm cells were also found in 6.6% of the cases. The characterization of the urinary parameters obtained in this study constitute the first reference data for this subspecies, which, when implemented along with veterinary physical examination and other diagnostic aids, can help monitor the health status of animals that are under human care, rescued, and in rehabilitation programs for later release.

Making fish feeding possible: How humpback whales avoid dispersing schools of maneuverable prey.

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All rorqual whale species feed on krill, but humpback whales are generalist foragers that regularly forage on larger, more maneuverable and more energy-rich fish of various species. This foraging flexibility has likely been an important factor in their 21st century recovery from 20th century whaling. While video evidence suggests that krill feeding has very low escapement, fish are highly maneuverable and will flee oncoming predators. The proportion of a school that can be caught has not before been calculated, nor has it been shown how humpback whales using whole body acceleration avoid rendering lunge-feeding inefficient by dispersing the school. In a first of its kind study we deployed combined video and accelerometer tags on anchovy-feeding humpback whales (n = 10), then used the engulfment and kinematic data to parameterize a looming-stimulus playback to anchovies in the laboratory. Anchovies were found to respond to the changing stimulus at a mean value (1.66 rad/s) that gives sufficient chance to escape from a sea lion-sized predator. Lunge-feeding humpback whales, however, can capture 40-50% of a school because they do not reach this threshold before engulfment begins close to the prey. Using field observations of humpback whale approaches from tags and the experimentally derived anchovy escape responses, we calculated how catch percentage, and thus foraging efficiency

(energy in/energy out), is determined more strongly by the timing of engulfment in relation to the school than by the timing of engulfment in relation to whale speed. These experiments both explain why humpback lunges on fish are not always kinematically efficient and also explain why lunge feeding on fish – which we found to have ~ 7x the efficiency of feeding on krill – is worth the extra costs of the pursuit and herding behaviors commonly observed in humpback whales.

Bottlenose dolphins (Tursiops truncatus, Montagu, 1821) and underwater noise pollution: Simulate the exposure of three Mediterranean groups..

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Underwater noise represents a relevant threat to marine mammals. Bottlenose dolphins (*Tursiops truncatus*, Montagu 1821) is a cetacean species categorized as "vulnerable" according to the International Union for Conservation of Nature Red List criteria as well as listed in Annex II of the Habitat Directive. This species inhabits coastal waters, which are notoriously subject to intense human use. This work focuses on the assessment of the anthropogenic noise disturbance on bottlenose dolphins in the surrounding area of the Port of Civitavecchia (northern Tyrrhenian Sea, Italy). The vocal plasticity of bottlenose dolphins in the study area was evaluated comparing recordings coming from other two Mediterranean areas (Pianosa Island and Sicilian Channel) representing two different scenarios: the first is closer to the study area and quieter due to the lower marine traffic, the second is far from Civitavecchia and characterized by an intense marine traffic.

The analysis of the whistles features together with an exposure simulation of local and foreign whistles datasets to the soundscape characterizing the Civitavecchia coastal area allowed to evaluate the noise pollution effect on bottlenose dolphins in terms of potential masking. Our data suggest a vocal behavior compensation, in terms of frequencies and intensity to the ambient noise, among the resident bottlenose dolphins. Bottlenose dolphin communications appeared to be masked by the ambient noise recorded in the main research area. Comparison obtained with the two datasets, suggests that they used to adjust some vocal behavior features to compensate the environmental noise. The results obtained from this analysis suggests that differences found in the vocal plasticity of bottlenose dolphins whistles seem to be directly proportional to the underwater noise of the area they inhabit even if geographical influences cannot be excluded.

Differential vulnerability to ship strikes between day and night for blue, fin, and humpback Whales based on dive and movement data from medium duration archival tags

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We examine the dive and movement behavior of blue, fin, and humpback whales along the US West Coast in regions with high ship traffic where ship strikes have been identified as a major concern. All three species are known to feed in coastal waters near areas of high ship traffic:1) the Southern California utilized by ships using the ports of LA/Long Beach, 2) the Gulf of the Farallones west of the ports in San Francisco Bay, and 3) the Strait of Juan de Fuca, the main access for ports in Vancouver and Puget Sound. We analyzed data from 33 archival tag deployments representing over 3,000 of data that were attached with suction cups or short darts for periods >24 hours and recorded depth (≥1 Hz), fast-lock GPS positions and other deployment-specific sensors. There were clear differences among the three species but all showed a distinct diurnal difference in diving behavior. While dive depth varied among animals based on where prey was located, whales spent a high proportion of their time closer to the surface where they would be more vulnerable to ship strikes at night than in the day. This was most pronounced for blue whales where vulnerability was twice as high at night compared to the day. We also found differences in movement patterns of whales between day and night. Movements were more localized to specific areas in the day near prey resources while at night these movements often involved directional movements (though sometimes circling back to the same area by the end of the

night). We show how in several specific areas like the Santa Barbara Channel, these differences in movements and locations translate to a very different overlap with shipping lanes at night compared to the daytime locations, which is the basis for most sighting data.

Working together to reveal the bigger picture: Tursiops truncatus truncatus movement patterns along the U.S. Florida east coast.

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East coast Florida common bottlenose dolphins, *Tursiops truncatus truncatus,* are distributed in a longitudinal continuum within inland waterways. Seven regional studies have identified local populations with resident and seasonally transient dolphins. However, study area boundaries limit understanding of distribution and movement patterns between these geographically separated regions. To reveal the bigger picture, a multi-organizational consortium conducted semiannual photo-identification surveys from the Florida-Georgia border to Titusville, Florida (331 km). The area was divided into segments to allow a one-day sampling period: S1 (FL-GA border to S2), S2 (St. Johns River), S3-5 (connecting waterways), and S6 (Mosquito Lagoon). During 28 surveys between August 2011 and January 2016 a total of 6,896 dolphins, including 196 neonates, were observed. Of the 222 distinct dolphins sighted in ≥5 seasons, 78% exhibited significant regional and seasonal fidelity to one or more segments. Habitat preference and spatial autocorrelation (SAC) analyses identified five main discoveries that no single study could elucidate. First, more dolphins avoided S1 (92%) than any other region; additionally, dolphins exclusive to S1 exhibited random distribution patterns and year-round site fidelity with sightings clustered seasonally. Second, small populations of year-round residents with significantly clustered seasonal sightings were identified in S2 (n=14) and S6 (n=48). Third, 87 dolphins utilized multiple segments. SAC analyses revealed that while these dolphins were randomly distributed within their range, their sightings were significantly clustered seasonally. Fourth, preference analyses, SAC analyses, and resight rates, coupled with the limited number of dolphins exclusive to each segment, suggest that S3 and S4 are passage zones and that S5 encompasses only part of individual dolphin ranges. Finally, resights among S2, S5 and S6 suggest that S5 is a key mixing area. Further collaborative studies of habitat use and behavior will help to explicate the year-round importance of these passage and mixing areas.

"Broken Heart Syndrome" in Cetaceans: Histological, histochemical and immunohistochemical study.

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Both humans and other animals, like cetaceans, have evolved mechanisms to cope with stressful situations in their lives. However, it is possible to develop different diseases when the stress is excessive or prolonged over time. An example is the Stress Cardiomyopathy (SCMP), also known as

"Takotsubo disease", "Broken Heart Syndrome", or "Apical Ballooning Syndrome", which is a reversible cardiomyopathy (CMP) in humans, most often occurring after an emotional or physical stress. Free-living cetaceans are threatened, daily, by a wide variety of stressful situations that affect their well-being and previous studies suggest that cetaceans would be especially predisposed to develop stress cardiomyopathies due to the characteristic of their cardiovascular adaptations. Different pathological entities have as central in its pathogenesis the acute stress so for this study we examined heart samples, from sixty-seven ashore cetaceans (48 stranded alive, 7 died from ship collision and 12 from bycatch) on the coast of the Canary Islands from 2000 to 2016 and on the coast of Andalucía from 2011 to 2014. As it occurs in the SCMP, all the above mentioned pathological entities share the same microscopic findings, characterized by acute or subacute cardiac degenerative necrotic lesions, presenting a perivascular pattern and consisting of: contraction band necrosis (49.25%), wavy fibers (43.28%), cytoplasmic hypereosinophilia and pyknotic nuclei (100%), perinuclear vacuolization (97.01%); vascular changes illustrated as congestion (67.41%), interstitial edema (38.81%) and hemorrhages (22.38%); infiltration of inflammatory cells (25.37%) and presence of interstitial myoglobin globules (43.28%). Immunohistochemically, it is also characteristic the depletion of cardiac troponin I, cardiac troponin C and myoglobin, besides the expression of fibrinogen in the degenerated/necrotic cardiomyocytes. Likewise, we intend to provide more knowledge about the pathologies and their implications in the conservation of cetaceans, through the reduction of mortality of these animals, their treatment and subsequent rehabilitation to the marine environment.

Observations during a springtime Bering Sea research cruise in a year of record-low sea ice extent.

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A warming climate is predicted to reduce the volume, extent and duration of Arctic sea ice. Ribbon, bearded, ringed and spotted seals ('ice seals') use sea ice in the spring as a platform for pupping, nursing and molting. In April 2014, 2016 and 2018, we conducted research surveys at the Bering Sea ice edge to collect samples and measurements from ice seals and to deploy seal-borne satellite-tags to record the seals' movements. In April 2018, the southern ice edge was 375 km farther north than in previous years, approximating conditions predicted by climate models after 2050. 2018 might therefore prove useful as a case-study for a future Bering Sea.

In 2014 and 2016, most of our sightings in the marginal ice zone were of ribbon seals, but we observed almost none at the more northerly ice edge in 2018. There were no reports of ribbon seals hauling out on shore in numbers that would explain their very low abundance at the ice edge, so ribbon seals may have moved west to occupy sea ice in Russian waters. April is the peak of pupping for ribbon seals and they are not known to pup or nurse in the water. If instead they remained in their typical breeding areas near the shelf break, they would likely have suffered a significant pup production failure.

There is evidence for a decline in the body condition (mass/length) and blubber thickness of spotted seal pups over the period 2014-2018 ($p<0.05$). The reasons for these declines are not yet known, but a more northerly ice edge would require nursing mothers to occupy areas farther from their usual foraging zones near the shelf-break. Reduced access to preferred prey could in turn, induce spotted seal mothers to produce less milk of sufficient quality, affecting the condition of their pups.

Bad management and vertical decision-making are tied with failure in the reduction of bycatch of Lahille's bottlenose dolphins (Tursiops truncatus gephyreus) in a protected area in southern Brazil

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In this work we investigated the artisanal fishermen's perceptions about Lahille's bottlenose dolphins and the gillnet fishing exclusion area in the Patos Lagoon Estuary and coastal areas, southern Brazil. This protection area (PA) was established by the Brazilian Government in 2012 aiming at reduce dolphin bycatch. Between April 2016 and December 2017, 49 artisanal gillnetting

fishermen were interviewed using a snowball approach and semi-structured questionnaire. During the interviews, fishermen were asked to draw the areas they use to fish and the geographic coverage of the PA in a map with known local references. Maps were digitalized and georeferenced in a grid of 20mx20m pixels, from which a series of information were obtained. None fishermen interviewed perceived dolphins as competitors nor reported bycatch. Most fishermen stated, "other fisheries, allowed to operate inside the protected area, incidentally capture bottlenose dolphins". According to the interviews, all fishermen are aware about the existence of a PA, but are ignorant about the reasons why this area was established and its boundaries. Maps analysis revealed that the mean fishing area (226km2) is much larger than the extension of the PA (95km2). This PA represents 38% of the mean gillnet fishing area. When operating inside the PA, fishermen uses 62% of its range, concentrating fishing effort where density of dolphins is highest. Therefore, we have verified that the artisanal gillnet fishing fleet continues to operate illegally within the PA and that other types of artisanal fisheries contribute to the bycatch – an information corroborated by recent records of bycatch during beach gillnetting and trawling activities. We diagnosed that the main reasons for the failure of the PA would be a top-down decision-making and the subsequent failure of the Brazilian government in the management process, which has caused serious social conflicts in the area where the environmental problem

Approach to a predictive model of habitat selection by blue whales (Balaenoptera musculus), based on satellite oceanographic measurements, between Chiloense Ecoregion and Corcovado Gulf, Chile (42° - 45°S).

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Blue whales, categorized as "*endangered*", frequent the inner sea of Chiloe (ISC) waters in Chile, intensifying their presence during the austral summer, associated with high productivity levels, being a key site for population recovery. Considering the spatio-temporal difficulties to register cetacean sightings, an alternative is the SDM studies through remote sensing. This research develops approximations to a predictive model for habitat selection by blue whales, through satellite oceanographic measurements.

Presence data were recorded from 2014 to 2017 during the summer of the southern hemisphere, between the Chiloense eco-region and the Gulf of Corcovado. Environmental satellite data was obtained from MODIS-Aqua. Spearman test was applied to determine correlation between parameters and presence data. To develop the predictive model, a species distribution model of maximum entropy (SDM-MaxEnt) was used.

Spearman's test indicates that the association of PAR + POC (r = 0,785), turns out to be the greater correlation that explains the habitat selection. Besides, MaxEnt model provides that the highest percentage contributions for environmental parameters was POC=45,1%, SST=33,5%, and Chl-a=11,2%. For this research, the habitat selection model places the highest probability of encounter in the Northeast area of the ISC.

Due to the high variability of the marine environment, determining habitat selection is a significant contribution to the ecology and distribution knowledge of blue whales. This allows us to develop a predictive model for habitat selection by blue whales, associating field observations with environmental parameters as predictors of habitat selection and the probability of encounter, in this intense climate change scenario.

Home and away: The importance of the Wild Coast of South Africa as a habitat for Indo-Pacific bottlenose dolphins.

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The Wild Coast of South Africa is characterised by the annual sardine (*Sardinops sagax*) run which attracts large numbers of top predators including cetaceans, fish, and birds during the austral winter. Adverse sea conditions and limited infrastructure have largely restricted research on cetaceans to aerial surveys during this sardine run. The importance of the region as a habitat for cetaceans is therefore, poorly understood. Here we present the main findings of boat-based photographic identification studies of Indo-Pacific bottlenose

dolphins (*Tursiops aduncus*) in the Wild Coast over the period 2014-2016. The study was conducted in three marine protected areas (MPA's), visiting each at least once per year and selected physico-chemical variables were measured. During this study, 2149 individual bottlenose dolphins were identified. The majority of animals (90%) were only observed once, with 225 (10.5%) re-sighted on 2-4 occasions, with an average of 305 days (range: 88-705) between re-sightings. However, 162 individuals (7.5%) were re-sighted within a 3-week field trip with an average of 3.7 days (range: 1-13) between these re-sightings. Importantly, 12 individuals were re-sighted in one MPA during all three surveys suggesting some degree of residency within the region. Environmental factors had minimal effect on individual and sighting density. Sea conditions limited surveys/time at sea leading to insufficient effort to estimate population size. Indeed, the discovery curve never reached an asymptote, indicating that a large portion of individuals remain to be identified. However, the number of individuals reported here is the largest for *Tursiops spp.,* suggesting that waters off southeastern South Africa are sufficiently productive to support huge numbers of dolphins. Moreover, findings suggest that the presence of sardines off the Wild Coast is not the only mechanism attracting these animals here and further research is necessary to understand bottlenose dolphin movement along the southeastern coastline of South Africa.

Influence of sample location on blubber cortisol concentration in striped dolphins (Stenella coeruleoalba)

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Given that hormone analysis can provide valuable insights into the animal physiology and the overall health status, considerable interest is focused in the measurement of cortisol as a physiological indicator of stress. In wild cetaceans, blubber sampled from projectile biopsies is one of the main matrixes used for cortisol analysis. The body location from which blubber is collected could potentially influence the levels of the hormone, but to date, no studies have yet addressed this issue. Therefore, the aim of the present study was to evaluate whether blubber cortisol is affected by the body region in striped dolphins (Stenella coeruleoalba). Subjects used were stranded dolphins found either dead or alive throughout the Catalan coast. Blubber samples were collected from 10 individuals at five different locations during necropsy: cranial and caudal areas in relation to the dorsal fin, and dorsal, central and ventral areas in relation to the pectoral flipper. Cortisol was extracted from blubber following an adapted organic-solvent extraction method and determined by enzyme immunoassay. Differences in cortisol concentrations across anatomical regions were tested by using a Friedman test. Mean (± SD) cortisol values obtained were as follows (values are reported as ng cortisol/mg blubber): cranial 7.45 (± 6.26), caudal 7.38 (± 5.69), dorsal 8.22 (± 7.31), central 8.53 (± 7.48) and ventral 10.31 (± 9.18). Cortisol levels did not vary with sampling location on the body (Friedman test: $X2(4) = 7.84$, $p = 0.098$), suggesting that hormone concentrations are uniformly distributed throughout the whole body blubber. In free-ranging marine mammals, blubber samples are usually biopsied by remote methods. This approach can be affected by the ability and training of the operator, likewise by the animal body size and swimming speed. Therefore, these results provide new evidence that potential inaccuracies of projectile biopsy sampling may not influence blubber cortisol concentrations.

Cuvier's beaked whales of Guadalupe Island: A possible resident population in a "natural laboratory" of México.

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Cuvier's beaked whale (*Ziphius cavirostris*) is one of the most abundant and widespread species of beaked whale in the world, and yet its natural history remains very poorly understood. A pilot

study undertaken at Guadalupe Island, México in 2009 revealed a high encounter rates of this species, as well as the presence of mother-calf pairs. Due to its low levels of human disturbance, as well as its protection as a Biosphere Reserve, Guadalupe Island represents a "natural laboratory" to research a rarely seen species in a relatively pristine environment. Recent field trips to Guadalupe Island were undertaken from October 2016 to November 2018. The search effort was conducted in a non-systematic manner. During 397.53 hours of search effort we recorded 210 sightings of Cuvier's beaked whales. Although surveys were conducted all along the east coast of the island, and a two-day circumnavigation around the island was also performed, beaked whales were exclusively sighted within Bahía Norte and Campo Lima, both with presence of submarine canyons. Group size ranged from 1 to 12 individuals, with a mean of 2.82 (SD = 0.44, N = 210). Only six of the total sightings included mother and calf pairs. The photo-ID catalog from Guadalupe, started opportunistically in 2006, now contains 76 unique individuals, including some whales with a sighting history spanning more than 10 years and recaptures of 33 whales across various time scales. These include a number of associated mom/calf resightings, which are critically important to understanding weaning in this species. A comparison of photo-ID catalogs to date has resulted in no matches between the Guadalupe population and the Southern California population. Therefore, results suggest a high degree of site fidelity among some of the sampled animals, and thus raise the possibility that this is an island-associated resident population of Cuvier's beaked whales.

Haul-out behavior of male Antarctic fur seals Arctocephalus gazella during late summer and early fall at the South Shetland islands

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Male Antarctic fur seals aggregate at male only haul-out sites in the South Shetland islands after the breeding season. We conducted visual census at Deception Island in early March 2019 to assess the demographic structure and population density at three haul-out sites (Collins Point, Whalers Bay, Baily Head). We also instrumented 14 subadult males at Collins Point and satellite tracked them from late summer to early fall to assess site fidelity and the duration of feeding and resting bouts. Demographic structure was rather homogeneous at the three sites and subadult males represented 46-63% of the population everywhere. Furthermore, males concentrated in the first 80 m above the water limit at the three sites, although adults concentrated in the first 40 m and subadults from 40 to 80 m above the water limit. Population density declined markedly 80 m inland, but some males moved as much as 220 m inland. Population density in the preferred part of the beach was much higher at Baily Head (10 males 400 m^{-2}) than at the other sites (Collins point: 6.2 males 400 m^{-2}; Whalers Bay: 4.7 males 400 m^{-2}), probably because of an easier access from the ocean. On average, the foraging bouts of subadult males lasted 5.7 ± 1.0 days and they rested at haul-out sites for 2.1 ± 0.6 days. Subadult males usually shifted haul-out sites between foraging bouts, which resulted in an extremely low site fidelity: only 5 out of 14 subadult males returned to Deception island at least once during the first 40 days after tagging and only 1 of them returned to Collins Point. Furthermore, 5 males leaved the Bransfield Sea to move south.

Population biology and abundance of Common Bottlenose Dolphins (Tursiops truncatus) in the Cap de Creus Marine Protected Area, North-western Mediterranean

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Common Bottlenose Dolphin (CBD), *Tursiops truncatus*, presence in the Cap de Creus Marine Protected Area (MPA) has the highest density for this species in the Catalan coast. However, no dedicated survey had yet been done in the area, which represents an important habitat for Mediterranean CBDs, classified as 'Vulnerable' by IUCN, due to underwater canyons present within two European Sites of Community Importance (including Cap de Creus canyon). In 2017 we started a two-year CBD study here to investigate this population through photo-identification surveys. 1183 nm of effective effort during 25 surveys days were carried out in 2017 and 1952 nm during 33 surveys days in 2018. 12 CBD sightings were recorded in 2017 and 36 in 2018. Average group sizes recorded were 8.3 (2017) and 10.3 (2018), however maximum group sizes were 25 (2017) and 46 (2018). Presence of calves was detected in 67% (2017) and 62% (2018) of the encounters. A total of 6897 photographs in 2017 and 21481 in 2018 were taken, from which best good-quality pictures were selected to be processed. Photo-ID efficiency was of 85% (2017)

and 100% (2018). 77 individuals (including 7 calves) were identified in 2017 and 388 (including 46 calves) in 2018; from these 71 (2017) and 337 (2018) were marked individuals. 4 recaptures were identified within 2017, 3 within 2018 and 4 between 2017-2018, resulting in 300 marked individuals being registered in this MPA's Bottlenose Dolphin Catalogue. Closed population capture-recapture models were used to assess abundance from left and right catalogues separately. 2017 left-catalogue data (n=45) resulted on a preliminary population abundance estimate of 239 (SE = 110, 95% CI 113-594). Results suggest this MPA could represent important breeding and feeding areas for the Mediterranean CBD population and, as fisheries interaction has been detected, also stress the need for further investigation.

Connecting conservation policy and marine mammal science: A survey of attitudes and trends in publications.

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Understanding attitudes about engagement in conservation policy within the marine mammal scientific community may help non-governmental organizations, federal agencies, and other management entities develop and enhance partnerships with scientists. To assess current attitudes and levels of engagement and how they have changed over time, we re-administered a survey and extended a literature review that were conducted in 2007 (Cornish and Daniel, Ocean Conservancy). In the 2007 survey, of the 305 respondents who were marine mammal researchers, 90.5% said their work had conservation implications and 59.3% believed they should engage in actions to promote marine mammal conservation. However, only 28.5% had engaged with federal, state or local government officials or agencies. In the twelve years since the initial study, social media use, the availability of science communication training, and public awareness and action around climate change and ocean degradation issues have increased significantly. Due to these and other influences, we expect the re-administered survey to reveal that the level of engagement has increased. We provided modern methods of science communication as survey response options and included questions about how researchers receive conservation policy information. In the previous literature review, of the 591 Marine Mammal Science journal articles reviewed from 1985-2007, less than 4% explicitly referenced conservation. However, almost 15% of the roughly 880 articles reviewed from the same journal for the shorter and more recent time period of 2008-2018 explicitly connect research to conservation. Our full literature review included other journals, such as Marine Policy and Aquatic Mammals, and considered keywords related to conservation, like 'policy' and 'management'. The results of this study will be shared broadly with survey respondents and with interested stakeholders looking to improve communication efforts for the conservation of marine mammals.

Do harbour porpoises (Phocoena phocoena) in the Baltic Sea prefer certain areas for foraging?

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Protecting foraging areas is essential in the protection of a species. The harbour porpoise population in the Baltic Sea is listed by the IUCN as critically endangered, and in this study we aimed at identifying areas important for foraging within its distribution range. Foraging buzzes, defined as parts of click trains with short inter-click-intervals (ICIs), were identified in the acoustic dataset from the SAMBAH project, which collected passive acoustic monitoring data from the Baltic Sea. The proportion of buzz ICIs to total ICIs was calculated per station per day per diel phase (dawn, day, dusk and night), and a general additive model was constructed to investigate if foraging areas could be identified within the harbour porpoise distribution range. Two main clusters of animals were evident in the data: one in the southwestern Baltic Proper and one in the Central Baltic Proper, with the sample size in the Central Baltic Proper being small compared to that in the southwestern Baltic Proper. Results show that on the scale of the 304 sampling stations (placed in a grid with 23.5 km between stations) no specific foraging areas could be identified. However, a significant difference could be seen in foraging activity between the two clusters, with a higher proportion of buzz ICIs in the Central Baltic Proper. Buzz ICIs were present in all diel phases, but the proportion of buzzes was significantly higher during night and dawn. Results are interpreted to agree with previous studies suggesting that harbour porpoises need to eat

almost constantly, meaning that foraging should occur in the entire distribution range and throughout the day. The higher buzz ratio in the Central Baltic Proper could indicate differences in porpoise foraging behaviour, prey species, and/or prey quality between the two porpoise populations.

The curious case of hairless seals.

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Hair loss has been observed in several marine mammal species and can have consequences for thermoregulation, impacting on metabolic rate and nutrition. Phocids spend a significant time on-land to breed, pup and rest, during which time fur contributes to an estimated 30% of thermal insulation. Alopecia, a condition of localized hair loss, has been observed in a number of seal species. Complete hair loss in seals has, however, rarely been reported in the wild. Here, we present, the first observations of apparent completely hairless grey (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) in Swedish waters. Hairless seals were identified from photos taken in august during the annual Harbour seal aerial surveys in 2015-2019. Each photo was combined with a GPS coordinate allowing us to pinpoint the locations of the hairless seals. The etiology of this condition is currently unknown and needs to be confirmed by close-up observations and sampling. As top predators marine mammals are ecosystem sentinels and the emergence of a hair loss syndrome may be an indicator of an ecological or biological disturbance in the marine environment.

Variation in ringed seal habitat use and feeding across a latitudinal gradient of sea ice.

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Ringed seals are vulnerable to rapid climate-driven sea-ice decline given their dependence on ice for subnivean lairs, moulting, and ice-associated prey. Ringed seals have a broad latitudinal range that experiences large variation in sea-ice coverage from transient coverage in their southern limits to persistent coverage in the north. Therefore, ringed seals likely adjust their habitat use and feeding to varying regional sea-ice conditions. Our objective is to investigate how the density, occurrence, and diet of ringed seals varies with sea-ice conditions across their latitudinal range. We conducted aerial surveys using infrared and digital imagery to obtain density estimates of ringed seals in Alert (82.5°N), Pond Inlet (72.7°N), and Arviat (61.1°N), Nunavut in May-June from 2016-2018. Pairing georeferenced sighting positions with high resolution remote sensing imagery allowed for novel investigation of fine scale habitat selection of ringed seals. Stable isotopes were used to infer trophic dynamics and highly branched isoprenoid (HBI) lipids identified the relative contribution of sea-ice carbon in ringed seal diets using muscle and liver from Arviat, Pond Inlet, and Grise Fjord, Nunavut (76.4°N), and Qaanaaq, Greenland (77.5°N) from September-November in 2015-2018. Ringed seal densities were highest at mid-latitude Pond Inlet (0.46-0.92 seals/km^2), intermediate in Arviat (0.45 seals/km^2), and lowest at high-latitude Alert (0.05 seals/km^2). Seals also selected limited first-year ice in the multi-year ice dominated Alert. Muscle samples (n=41) significantly increased in δ^{15}N from 15.61‰ to 16.48‰ ($t=2.88$, $p=0.0063$) and decreased in δ^{13}C from -21.15‰ to -19.76‰ ($t=11.26$, $p<0.0001$) between Arviat and Pond Inlet, respectively. Liver samples (n=44) similarly increased in δ^{15}N ($t=3.23$, $p=0.0024$) and decreased in δ^{13}C ($t=15.62$, $p<0.0001$) between Arviat and Pond Inlet. Results from HBIs will also be discussed. As sea-ice decline continues, our results provide insights into how a key Arctic species adjusts to regional sea-ice conditions and inform co-management with northern communities.

Human influence on common bottlenose dolphin (Tursiops truncatus) strandings in the northern Gulf of Mexico

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Human interactions (HI) with marine mammals pose a threat of increasing global concern for conservation, but human activities can also benefit stranding response through enhanced monitoring and reporting of stranded animals. The net effect of these human influences on stranding demographics is not well studied but has potential to influence stranding numbers and how we manage and conserve populations. To quantify human influence on stranding events in terms of direct contributions to strandings and stranding response effort, we determined the number and proportion of total and HI-related bottlenose dolphin (*Tursiops truncatus*) strandings normalized to shoreline length in each northern Gulf of Mexico (nGOM) state. We used the Deepwater Horizon oil spill (DWHOS) as a benchmark to compare periods of lower (pre-) and higher (post-DWHOS) response effort. Alabama was used as a case study to define potential interannual and spatial variation in human influences on strandings because sufficient data were available to make comparisons for this state. Our findings indicate a region-specific increase in strandings along the nGOM coast from Louisiana through Alabama, with the greatest proportion of HI strandings in eastern nGOM (Alabama, western Florida). While the overall increase in stranding numbers is likely due to a combination of increased stranding occurrence and response effort following the DWHOS, HI-related standings increased independently from the DWHOS. Alabama was identified as a hotspot of HI strandings, having the highest density and percentage of (non-oiled) HI strandings since 2010, primarily fishery interactions. This study highlights the: 1) value of high-quality local and regional data to support analysis of patterns in marine mammal stranding events, 2) need for sufficient monitoring and stranding network operations, and 3) importance of understanding negative and positive human influences on stranding demographics to support targeted conservation efforts.

New kids on the block! Studying stereotyped whistles in a resident population of common bottlenose dolphins

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The Sado estuary, Portugal is home to a small, resident population of common bottlenose dolphins (*Tursiops truncatus*) that have been the focus of multidisciplinary research. The long-term occurrence of stereotyped tonal calls has been documented for more than 20 years, and these emissions with stable frequency modulation contours have been hypothesized to be signature whistles. These whistles are thought to broadcast individual identity, and are considered important vocalizations to maintain cohesion in bottlenose dolphin groups. In order to support the attribution of signature function to stereotyped whistles, the SIGID criterion has been applied to field recordings. This study attempts to document the occurrence of new signature whistles in a well-known, stable population where newborns were observed recently. From 2016-2018, bottlenose dolphins' underwater emissions were recorded and the composition of groups was assessed using photo-identification. The complete census of this population during this study was at 31 individuals: 25 adults, 2 juveniles, 4 calves. Based on the acoustic analysis, 169 good-quality whistles were identified, and classified into categories by four independent judges, through visual inspection of spectrograms. A total of 11 stereotyped whistle contours were identified, of which 4 were detected for the first time. Interestingly, during the same period of time 4 new calves were observed. Only three whistle types were validated as signature whistles by the SIGID method: two previously identified contours and one of the new additions. Work is in progress to explore the link between recorded stereotyped whistles and identified individuals in the groups of these resident bottlenose dolphins.

Monitoring marine mammals in Brazil: Beyond the legal commitments.

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Since 2015, marine mammals have been monitored by two different projects conducted by PETROBRAS to attend legal commitments established by the brazilian environmental agency, IBAMA, for the environmental licensing process of Santos Basin pre-salt province oil production and transport . They are the biggest monitoring

programns in course in the country considering the area covered and the types of methodologic aproaches. One of them is called Santos Basin Cetaceans Monitoring Program and the otlher is called Santos Basin Beach Monitoring Program. The collected data are public acessible and the information that has been produced is fundamental for the brazilian biodiversity action plans update and definition of new ones. Both of them have been executed by companies and universities, allyng cientific knowledge with mannagemente practices contributing to biodiversity conservation.

Protecting one endangered species at the expense of another? Evaluating the efficacy of vessel speed restrictions in reducing lethal vessel strike risk to blue and right whales in the Gulf of St. Lawrence.

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North Atlantic right whales (NARWs; *Eubalaena glacialis*) and blue whales (*Balaenoptera musculus*) are listed as endangered under the Canadian Species at Risk Act. NARWs were recorded in the GSL as early as 1976, but not observed in large numbers until surveys began in 2015. Surveys have reported consistent blue whale presence in the GSL since they began in 1979 and individuals have been recorded in elevated vessel traffic areas including the GSL shipping lanes. Shipping traffic has been identified as a threat to both these species in their respective recovery strategies.

Since the 2017 NARW unusual mortality event where 57% of necropsied carcasses showed evidence of vessel collision, vessel-strike mitigation in much of the GSL has consisted of seasonal speed restrictions aimed at reducing the probability of lethal vessel strikes for NARW. Necropsy evidence has not initiated protection for blue whales as their carcasses sink after death and are less likely to be necropsied.

Despite the NARW (est. 411 individuals) and Northwest Atlantic blue whale populations' (est. <250 adults) endangered statuses, current GSL vessel strike mitigation focuses exclusively on NARWs. Though blue whales are sighted in the GSL shipping lanes, speed restrictions are not triggered by their presence. Additionally, the extent of the speed restriction zone does not include high density blue whale aggregation areas such as the Saint Lawrence Estuary.

This study aims to evaluate the efficacy of the static speed restriction zone and dynamic shipping sections in reducing lethal vessel strike risk to blue and right whales using Automated Identification System (AIS) vessel traffic information, whale sightings and visual survey effort data. This is achieved through identifying areas of elevated risk for each species, evaluating changes in risk, and assessing whether risk to blue whales increased as a result of the current management scheme for NARWs.

Characterization of degenerative diseases on marine mammals of Peru: Increased incidence over 10 years.

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Research and data on marine mammal health in Peru has been recorded over the past 18 years by the Organization for Research and Conservation of Aquatic Animals (ORCA). This presentation provides a clear description of degenerative diseases currently affecting marine mammal in the Peruvian waters. Seven species were recorded stranded between 2008 and 2018. Samples collected included skin, blubber, liver, heart, lymph nodes, intestines, stomach, bladder, lung, and blood. Characterization of degenerative disease included external clinical signs before death: emaciation, bone projected lumps from hips, lumbar vertebrae, shoulders, ribcage, chest and rostrum; transparent discharge from nose, weakness, limping, pale mucous or cyanosis, lethargic behavior, dyspnea, hypoxia, and dehydration. Necropsy abnormalities showed ascites or hydrothorax, abnormal coloration of intestines, hyperplasic bladder, heart with hyperplasia on left or right side, hemoprotein liquid in abdomen or thorax, lung collapse with veins constricted and hemorrhoidal white structures, and white solid structures around thoracic or abdominal organs. Formalin fixed samples with H-E stain confirmed neoplasm in 83% of the cases (N=103). Acquired data has shown the significant increase of degenerative cases between 2008 and 2018. from 1

to a median of 12 per year, with a peak of 36 cases recorded in 2017. The impact of oncogenic pollutants on marine mammals plays a critical role in understanding population dynamics and disease risks. As oceans continue to increase in pollutant levels, marine mammals are playing a critical role as sentinel species for possible physiological effects that could occur in humans, as occurrences of neoplasm originating in the lymph nodes and lungs correlated with mercury toxicity. An analysis of known effects of pollutants and areas of needed research will be outlined based on these cases. Understanding the impact of focalized pollution will be a strong aid in determining the next steps towards restoring the ocean's health.

Circumpolar southern right whale foraging ecology and population recovery: Insights from isotopes.

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Southern right whales (*Eubalaena australis*) are slowly recovering from several centuries of exploitation. While extensively studied on coastal wintering grounds, the species' foraging ecology on offshore summering grounds remains poorly understood. This knowledge gap needs to be addressed, as there is a growing body of evidence that environmental conditions on high-latitude foraging grounds shape population dynamics, and behavioural mechanisms may limit the ability of the species to adapt to predicted shifts in prey distribution linked to climate change. Therefore, it is likely that the quality and predictability of food resources will be a major factor in population recovery. This hypothesis has formed the basis for a Southern Ocean Research Partnership (SORP) theme entitled 'The right sentinel for climate change', which aims to link foraging ground variability to population recovery in the southern right whale. We will present progress on a SORP-funded global initiative based on a large carbon (δ13C) and nitrogen (δ15N) isotope dataset derived from skin samples collected from Argentina (n = 250), Australia (n = 84), Brazil (n = 49), Chile (n = 1), New Zealand (Auckland Islands n = 460), and South Africa (n = 131). A validation study to account for variation in lipid-extraction procedure by different primary labs is underway using a subset of samples. The standardised dataset will be analysed to investigate differences in skin isotope values related to region, sex, and collection era. The skin isotope data will then be compared to Southern Ocean δ13C and δ15N isoscape values. By matching whale skin isotope composition to isotopically distinct regions within the isoscape, after adjusting for trophic discrimination and accounting for sources of error, we aim to identify the most likely locations for an individual's summer foraging grounds. Ultimately, habitat models will be generated to describe the

environmental characteristics of these foraging grounds.

Predicting the at-sea distribution of sympatric grey and harbour seals in the United Kingdom using habitat preference models

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The United Kingdom hosts globally important populations of both grey and harbour seals. While grey seal numbers have increased steadily over the last 60 years, harbour seals are experiencing dramatic population declines in some regions, with no causal factor identified. The distribution of both species overlaps in many areas. Grey seals have been reported to predate harbour seals, and their similar diets suggest that they may also be competitors. These factors, coupled with increasing potential for anthropogenic disturbance due to offshore construction and habitat modification, mean that there is a growing need to understand the drivers of at-sea distribution for both species. Previous studies have predicted at-sea distribution based on patterns of space use derived from telemetry data. However, this approach does not allow robust predictions of distribution emanating from haul-outs for which there are no associated telemetry data. Using high-resolution GPS tracking data from 95 grey and 280 harbour seals, we modelled regional habitat preference as a function of environmental covariates in a use-availability framework. Environmental drivers of at-sea distribution varied between the species and among regions, highlighting the complex spatial dynamics of phocid seal ecology in the UK. Spatial predictions of seal distribution were scaled by population estimates at each known haul-out site, and merged to create a UK-wide distribution map for each species for use in marine spatial planning.

Gender-based differences in body condition in humpback whales on the Hawaiian breeding grounds during a period of reproductive decline

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Between 2013 and 2018, as three potent climatic disruptions impacted the North Pacific, we documented a steep decline in the reproductive rate for the newly designated Hawaiian Distinct Population Segment of humpback whales, *Megaptera novaeangliae*. Encounter rates for mother-calf humpback whale pairs within our study area on the Hawaiian breeding grounds fell by 75% during this period. Additionally, while numbers of adult whales stayed relatively constant, anecdotal reports of malnourished whales increased during this time. Here, we provide regional encounter rates for the 2019 season, along with quantitative details of body condition for maternal females and likely males during this period of disruption. Beginning in 2016, we collected aerial imagery of samples of all cohorts using a small UAS. To address the limitations of the onboard altimetry included in the UAS, standardized calibration data were collected within each flight. Using still images extracted from aerial video and standard photogrammetry software, we collated details of body morphology and calculated the ratio of the dorsal surface area to body length to provide a condition estimate for each individual. Results highlight gender-based differences over this period. For maternal females, body condition remained consistent throughout the aerial study period (2016-2019). In contrast, for likely males (i.e. escorts to mother-calf pairs and adults seen in multiple groups, presumed mostly males), body condition estimates increased by 16% in the 2019 season compared to previous years ($t = -2.940$, $p = 0.007$). Combining these findings with our sighting data suggests a gender-specific response in migratory behavior during this time. Potentially, males, albeit in lesser body condition, migrated to the breeding grounds throughout this period of nutritional stress. In contrast, female reproductive activity and associated migratory behavior may have been constrained by body condition during these challenging times.

Passive acoustic platforms to investigate spatiotemporal patterns in distribution and acoustic behavior of Indo-pacific humpback dolphins southwest of Hainan island, China.

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Passive Acoustic Monitoring (PAM) offers a non-invasive and reliable method to survey acoustically marine mammals and provide information on their distribution and activities at high spatiotemporal resolution. Indo-Pacific Humpback dolphin (*Sousa chinensis*) is a species inhabiting the tropical and warm-temperate waters of the eastern Indian Ocean and Southeast Asia and a new record was logged in 2014 in the coastal waters southwest of Hainan Island (South China Sea). The significant recent increase in coastal development in this area, related to economic growth linked with touristic business, has resulted in several activities (e.g. seashore construction, coastal urbanization, artificial islands) that could impact the dolphin habitat. We are investigating the long-term distribution of this population using an array of underwater platforms installed in shallow waters (10-20 m depth). In each PAM site, an acoustic stationary recorder (SoundTrap) is installed periodically from Feb 2018. A sampling frequency of 288 kHz with 16-bit quantization was chosen. We established a recording sampling protocol of 5 min every 30 min, with about two months of data acquisition with no-battery recharge. The PAM survey that we are applying with multiple platforms encouraged us to use automatic analyses methods. A detection algorithm was developed in MATLAB to identify echolocation signals (clicks) of Indo-Pacific humpback dolphin. Here, results on species distribution are presented across multiple temporal and spatial scales. Moreover, the accuracy of click detection process was examined through the different locations and compared with an acoustic click data logger (A-tag) installed in each platform. The acoustic presence of dolphins was checked via manual approach (spectrogram visualization and listening, Raven Lite software) and other signals of interest (natural, biological and anthropogenic sources) were identified in correspondence with dolphin vocalizations.

Spatio-temporal characterization of cetacean strandings and main causes of mortality along Western Southern Iberia, 1978-2017

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Cetacean strandings data can provide insights into the long-term dynamics of populations, and threats they face. This work investigated cetacean strandings collected along the southern Portuguese coast (Algarve) between 1978 and 2017, seasonal and annual trends in the number of strandings for all strandings identified to specie level (N = 887), and for the five most frequently reported species: common dolphin, *Delphinus delphis* (39.0 % of records), striped dolphin, *Stenella coeruleoalba* (9.8 %), minke-whale, *Balaenoptera acutorostrata* (7.7 %), bottlenose-dolphin, *Tursiops truncatus* (7.4 %) and harbour porpoise, *Phocoena phocoena* (4.2 %). Analysis showed that the relative frequency of strandings on the overall and for the five most stranded species increased significantly recently in the most recent period (2010-2017). Seasonal peaks in strandings frequencies were only significant for minke-whale, between March and June. Strandings of all species, but especially bottlenoses and porpoises, occurred more frequently on the leeward (eastern Algarve) side of the coast. Of the 887 cetaceans strandings registered, it was possible to investigate the cause of stranding for 450 cetaceans (50.7%) and about 50 % of these individuals died of anthropogenic causes, mainly due to bycatch in fishing gear (31 %). The main factor we suggest that could be responsible for the increases in cetacean strandings in southern Portugal in recent years is mainly increased survey effort. Fisheries interactions, especially with coastal gears (gill and trammel nets, purse seine) are in significant part responsible for mortality patterns for smaller delphinids and porpoises and worthy of more detailed investigation. These results highlight the ecological significance of strandings data from long term databases as a valuable monitoring strategy in the region.

Ontogenetic and sex-related diet variation in Amazonian manatees (Trichechus inunguis) from central Amazon, Brazil

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Variation in resource use among ontogenetic classes and sexes have been reported for many aquatic mammals. For species that inhabit areas of difficult access, as the endemic Amazonian manatee (*Trichechus inunguis*), there are few studies focused on feeding ecology, these ecological questions remaining unanswered. Therefore, the aim of this study was to assess variation in the diet of Amazonian manatees from Amanã and Mamirauá Sustainable Development Reserves, Amazonas, Brazil. Amazonian manatee's dentin and the potential food sources (algae and macrophytes) were analyzed for carbon and nitrogen stable isotopes. Mixing models were used to estimate the proportion of each food source that contributes to the diet and simulated mixing polygons were created to verify the adequacy of the trophic discrimination factors used. Sex and ontogenetic-related variation in $\delta^{13}C$ and $\delta^{15}N$ values were evaluated through generalized linear models. For all the adults and male adult groups the highest dietary contributor was C_4 plants, while for juveniles and adult females, C_3 aquatic plants contribute more. However, differences in contribution between C_4 and aquatic C_3 plants were small for all groups (0.04 to 0.18). The best model (lower AIC) for $\delta^{13}C$ included only the variable ontogenetic class and for $\delta^{15}N$, sex and ontogenetic class. Adults showed higher $\delta^{13}C$ values (-16.1‰), followed by juveniles (-18.2‰) and nursing calves (-20.5‰). The lowest $\delta^{15}N$ values were observed in juveniles (8.5‰) and females (8.9‰), and the highest values in nursing calves (9.9‰) and males (9.7‰). In conclusion, the differences in stable isotopic values among ontogenetic classes are probably reflecting the distinction between nursing calves' milk diet and adults' solid diet, which is commonly reported for other aquatic mammal species. Sex-related variation were attributed to different habitat use patterns due to distinct energetic reproduction demands, where males would travel larger distances searching for a receptive female.

Emerging contaminants in humpback whales (Megaptera novaeangliae) foraging in Antarctic waters, and their impact on whale fibroblast cell viability

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The marine environment is susceptible to contamination by both natural and synthetic persistent organic compounds, with long-lived cetaceans at the greatest risk of accumulating lipophilic chemical burdens. The physico-chemical properties of most persistent organic pollutants (POPs) favour their transport to high latitude or altitude environments, with the poles of the Earth representing important environmental sinks for these compounds. In this study, a number of modern POPs, namely polybrominated diphenyl ethers (PBDEs) and short-chain chlorinated paraffins (SCCPs), as well as the naturally occurring brominated compound, 2,4,6-tribromoanisole (TBA), were detected in the blubber of southern hemisphere humpback whales, known to feed almost exclusively in Antarctic waters. BDE-47 and BDE-99 were present at the highest concentration and were the most frequently detected, confirming their ubiquitous presence in the global environment and their bioaccumulation potential. TBA, a compound that has raised concern due to its structural similarity to PBDEs, was similarly detected in the majority of samples. SCCPs were detected for the first time in any baleen whale species, and any Antarctic foraging mammal, providing valuable information regarding the distribution of these newly listed POPs. Selected congeners of these chemical groups were exposed to the newly established immortalized humpback whale fibroblasts cell line ($HuWa_{TERT}$) to evaluate their toxicological effect on species-specific cell viability. A dose-significant effect was observed for BDE-99, with a dose-dependent increase in cell metabolic activity and decrease in membrane integrity. Interestingly, this trend was the reverse for the positive control (*p,p'*-DDE). Clear dose-dependent trends were not observed for BDE-47, TBA or SCCPs. This *in vitro* effect-assessment model provides valuable insight into species-specific toxicological sensitivity and should be further applied to a broader range of known and emerging chemicals of concern and their mixtures to help fill the knowledge gap surrounding cetacean sensitivity to accumulated chemical burdens.

Results of diagnostic activities on stranded cetaceans, Italy, 2017-2018

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Thanks to the surveillance activity of the Istituti Zooprofilattici Sperimentali network, coordinated by the National Reference Centre for Diagnostic Activities on Dead Stranded Cetaceans (C.Re.Di.Ma.), the examination of cetaceans stranded in recent years along the Italian coastline has shown that infectious diseases play an important role as cause of death (CD). During the two-year period 2017-2018, 184 out of the 386 cetaceans stranded along the Italian coastline (Italian National Stranding Database) were necropsied (47.6%). The necropsy and the panel of diagnostic investigations were either complete or partial, depending on the conservation status of the carcass. Based on gross and microscopic pathology and ancillary testing, the most probable CD was determined and categorized as anthropogenic (sub-classified into interaction with fishing activities/vessel collisions), infectious (sub-classified into viral/bacterial/parasitic/mycotic), by other causes (including metabolic and degenerative disorders, neonatal/perinatal pathology, etc.), and undetermined. The CD was determined for 120 animals (65%). Infectious diseases were the most common CD, involving 72 cetaceans (60%), while 40 specimens (34%) were diagnosed with an anthropogenic CD, consisting in interaction with fishing activities in most cases, and 8 (6%) were considered as affected by other CDs, mostly perinatal pathology. Noteworthy, the diagnostic activities allowed to detect well known cetacean-specific viruses like *Dolphin Morbillivirus*, cetacean *Alphaherpesvirus* and *Gammaherpesvirus,* as well as significant pathogens like *Salmonella* 1,4, [5], 12: i: - and *Salmonella* Enteritidis*, Listeria monocytogenes*, *Erysipelothrix rhusiopathiae, Brucella ceti* and *Toxoplasma gondii.* These results, integrating novel findings and published reports, are valuable for a baseline knowledge of cetacean pathology and mortality trends in the Central Mediterranean Sea and may be helpful to diagnosticians and future conservation policies.

Preliminary mark-recapture analysis of striped dolphins (Stenella coeruleoalba) photo-identification data in the Aeolian Archipelago, Italy.

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A long-term photo-id study was performed on Mediterranean striped dolphins (*Stenella coeruleoalba*) inhabiting the Aeolian Archipelago (Southern Italy). Data collected through 412 focal follows on April-November from 2007-2018 were used to investigate striped dolphin distribution, habitat use, degree of residency and pattern of skin marks. A photo- ID catalogue of the photo-identified individuals was produced (DARWIN) and a high re-sighting rate was found in mark-recapture analysis. The prevalence of skin mark types found on dorsal fin and the other body regions (head, flanks, back, tail and flukes) was assessed and classified according to traumata or other causes. The distribution of striped dolphin groups varied with season, i.e. a more homogeneous distribution was found in the summer whereas more localized feeding habitats in spring/autumn, suggesting that the dolphin groups may move according to prey availability but also to anthropogenic factors such boat traffic. The offshore occurrence of the dolphin groups was related to a mean depth of 420.6 meters and a mean

distance to coast of 2455 meters. These results suggest that the Aeolian Archipelago is an important feeding area for Mediterranean striped dolphins and contribute to implement appropriate management actions for the conservation of cetacean species in this area.

Integrating remote sensing methods to measure social delphinid baseline behavior and responses to navy sonar

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Oceanic delphinids are not endangered and typically have not been observed in mass-stranding events associated with military sonar, but include common protected species (*e.g.,* common, bottlenose, Risso's dolphin*s*) that are exposed in high numbers to sonar in some areas. We integrated existing research methods in novel ways to: (1) measure broad and fine-scale group and individual baseline behavior; (2) conduct the first-ever controlled exposure experiments (CEEs) to measure group-level responses to mid-frequency (3-4 kHz) active sonar (MFAS); and (3) obtain measurements of potential physiological stress responses arising from noise exposure. Our approach consisted of complementary sampling methodologies to measure the behaviour and physiology of several dolphin species, including shore- and vessel-based visual sampling, a long-endurance (>30 min) octocopter unmanned aerial system (UAS) for photogrammetry and behavioural sampling, drifting passive acoustic recorders, and biopsy sampling to detect stress response from blubber cortisol levels. During three field efforts, over 100 different groups were sampled. Shore-based theodolites generated tracks and speeds of overall group movement and social dynamics. UAS-based photogrammetry analysis measured the location and body length of > 335,000 individuals to describe group structure. Individual animal positions were then mapped in high spatial (cm) and temporal (s) resolution, enabling a detailed evaluation of individual heading, spacing, and speeds. Acoustic measurements of group vocal behavior were analyzed to compare vocal rates before, during, and after CEE exposure periods. CEE sequences were conducted (n=20 total across all focal species) in both no noise (control) and MFAS exposure conditions. The resulting data is categorically different from previous CEEs on single tagged individuals, appropriately so given the gregarious social nature of these species. Preliminary results demonstrate temporal changes in stress hormone levels following exposure and strong group-level responses in some, but not all conditions, with some indication of species and context-dependent differences.

Parameterizing dolphin behaviour with animal-attached tags to study acoustic communication

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Many studies of acoustic communication classify vocalizations and examine how call categories are used in relation to behavioural states and events. Acoustic parameters of signals can also convey information independent of what call type is used, and can grade within or across call categories thus encoding information on a continuous spectrum. This offers complementary study approaches to call classifications. While animal movements are also frequently resolved into discrete classes, animal-attached tags enable continuous sampling of high-resolution behavioural data, which is valuable for testing how continuous acoustic parameters relate to the graded patterns of animal motion. Here we illustrate this approach through case-studies on

wild common bottlenose dolphins (*Tursiops truncatus*). We used data from sound-and-movement recording tags (Dtags) deployed in Sarasota Bay (FL), and parameterized dolphin vocalizations and motion to investigate how senders and receivers modified movements as a function of signal parameters (centroid frequency, modulation rate, spectral occupancy, duty-cycle). We used vectorial dynamic body acceleration (VeDBA) as a proxy for activity intensity during agonistic social interactions, and found that: 1) VeDBA of a female during reproductive consortships had a negative relationship with the frequency of male calls (-0.21 (m/s^2)/log(Hz)); 2) VeDBA of four males had a positive relationship with the modulation rate of their pulsed vocalizations (3.24 (m/s^2)/kHz). When comparing our acoustic parameters across sound categories of bottlenose dolphins (747 sounds from 11 deployments), we found that categories could not be clearly distinguished on the basis of these parameters combined (DFA correct-classification rates: 9% to 90%). Altogether, our results suggest that our chosen parameters are less involved in defining call categories, but help encoding information independent of what category is produced. Tags allow studying behaviour through analyses of multivariate quantitative patterns. Our study illustrates the value of these analyses to shed light on the communicative role of acoustic parameter changes.

Getting way too close to wild dolphins and manatees: Challenges of marine mammals watching tourism in Sian Ka'an Biosphere Reserve (SKBR), Mexican Caribbean.

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Marine mammal watching is becoming an important non-consumptive use of wild megafauna in Mexico, mainly in the Pacific and Gulf of Mexico. Here, we present the first report of watching tourism targeting dolphins (Tursiops truncatus) and manatees (Trichechus manatus manatus) in the Mexican Caribbean (SKRB). We applied 64 semi-structured interviews to tourism operators and fishermen of Punta Allen and Punta Herrero communities, in order to compilate information about the offered tours, watching protocols and local perception. Based on this, we selected key localities to observe and describe watching activities and when possible, the animals' reaction to the boats. For manatees, two zones near sinkholes located in Caapechen and Bocapaila lagoons were selected, and observations were video-recorded using a drone DJI Phantom 3 Advanced. A locality known as 'El Faro' was visited to conduct boat-based observations of dolphin watching activities, assessing surface dolphin behavior by focal group sampling over two-minute intervals. Manatee watching tourism is conducted by two methods: stationary observations and active chasing, the latest representing a potential risk of collision for the manatees. Likewise, during dolphin watching activities we observed concerning boat operators behaviors: direct and close approaching to the dolphins, aggressive chasing, and excessive number of boats interacting with the same group. Five local tourism cooperatives and two private operators offer manatee/dolphin watching tours to visitors, showing that this is an important source of income to community stakeholders. However, our observations raise a concern as it could be detrimental to the target species. After several workshops/meetings with the local tourist operators and SKBR authorities, we propose guidelines for watching activities in order to reduce the risks of marine mammals' behavioral changes, habitat use modification and boat collisions. Likewise, establishing temporal or spatial refuges protecting biologically important areas (e.g., feeding grounds) where watching activity is prohibited, could be an appropriate strategy.

Improving our understanding of Cook Inlet beluga disturbance by anthropogenic noise

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Following a dramatic decline, the Cook Inlet beluga (CIB) population was listed as endangered in 2008. A decade later, this population, currently estimated at 328 whales, has shown no sign of recovery, with the cause of this lack of recovery unclear. One major threat to this population is anthropogenic noise. CIB critical habitat is concentrated near Anchorage, which is the largest urban area in the state and home to the majority of Alaska's human population. CIB are exposed to a wide variety of potential noise stressors including fishing, mining, dredging, military operations, oil and gas development, air and water transportation, and residential and industrial shore development. Many of these activities are intensified during the belugas main foraging season when ice is absent (May-October). NOAA Fisheries regulates noise exposure under both the U.S. Marine Mammal Protection Act and the U.S. Endangered Species Act. However, noise impact mitigation is limited to close-range effects defined by the onset of injury (i.e. temporary and permanent hearing threshold shifts). Previous acoustic monitoring data showed how noise levels regularly exceed behavioral harassment thresholds in CIB critical habitat. To address this concern, an acoustics research project was initiated in 2017 to identify foraging areas based on foraging behavior documented with suction cup multisensor tags, and examine the potential disturbance by anthropogenic noise in these ecologically important areas, using year-round acoustic moorings. This presentation will summarize our current understanding of the temporal and spatial overlap between anthropogenic noise and beluga foraging behavior, and our initial results on potential displacement from foraging grounds.

Friendly whales? Unusual behavior of humpback whales that are possibly accustomed to tourism.

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Whale watching is one of the fastest growing tourism industries in the world. In Latin America whale tourism is in constant growth. In 2014, the fishing community of Puerto Lopez received more than $3,000,000 USD between direct and indirect profits and 60,000 tourists from June to September. Our main research objective is the population study of the humpback whales *Megaptera novaeangliae* and our research question is to know the impact of tourism on whales.

Our study area is located in Puerto Lopez, Machalilla National Park, Ecuador, which included Isla de la Plata. From 2016 to 2018, 180 research trips were realized, of which 15 (8%) instances of ´´friendly whales´´ have been observed. Pod sizes varied between one to fifteen animals. The most common behaviors observed: the competitive, travel and rest groups.

Friendly whales are curious whales that during the whale watching tours come close to the boat and stay around it, from five minutes to one hour. There are reports of whales touching the boats without moving, allowing the tourists to touch them. There are others that on various occasions will stay next to the boat doing spy hops and traveling around it.

This study aimed at understanding the behavioral reactions of individuals to these interactions with whale watching boats. Observing the behavioral events performed by individuals during an interaction can help define the short-term reactions elicited by the boat presence. We recorded the behavioral events performed by all individuals. The frequency of occurrence of all events was compared depending on the presence of vessels, their behavior, and the structure and composition groups.

This document proposes the naming of "friendly whale" as an unusual behaviour of the humpback whales in the presence of humans and whale watching boats. We suggest more studies on the behaviour, in other breeding areas, to determine if the growth of tourism is changing the behaviour of the whales and accustoming them to human presence.

Assessing the impact of drones on the behaviour of small dolphins

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Unmanned Aerial Systems (UAS), commonly known as drones, have recently emerged as an inexpensive and accessible alternative to study marine wildlife. The Vertical Take Off and Landing (VTOL) are probably the best UAS type for behavioural studies. They provide cheap, stable, non-intrusive and highly maneuverable platforms to study single individuals or small groups of animals. Although studies with VTOL UAS have been done with various species of marine mammals

very few behavioural responses specific to these types of devices have been recorded. Considering the wide accessibility of UAS's, it is essential to understand their impacts on these animals. This study intends to determine the behavioural response of two different species of Delphinidae, the common dolphin (*Delphinus delphis*) and bottlenose dolphin (*Tursiops truncatus*) to a VTOL UAS at different altitudes. For this work we used a multi-rotor (quadcopter) UAS type with a Go Pro camera attached. Once the dolphin group was found, the starting height of UAS was 50 m , subsequently dropping 5 m every 30 sec until reaching 5 m. Three variables were considered to analyse the immediate response of the group at different UAS heights: changes in direction, increase in speed and diving behaviour. Responses by *D. delphis* (n=15) and *T. truncatus* (n=10) groups were analysed separately. Cochran's Q test revealed no significant responses of *T. truncatus* to any of the studied variables. However, changes in direction were statistically significant ($Q=18.000$; $p<0.05$) for *D. delphis*, with increased changes in direction apparent at altitudes of 5 m. We strongly recommend that VTOL UAS's fly above small cetacean groups at a minimum height of 20 m. To summarise, the use of VTOL UAS in small cetacean studies seems a very good option with minimal impact on the animals.

Automated pixel-based tool for assessment of body condition in large whales.

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Marine ecosystems around the planet are undergoing unprecedented change and its species are facing increasingly variable and potentially inhospitable habitats, as evidenced by large-scale die-offs of numerous marine species. In order to keep abreast of change, researchers need tools that can quickly gauge the health of marine species. With recent advances in Unmanned Aerial Vehicle (UAV) technology, the ability to collect such data has never been greater. However, the ability to analyze this data efficiently is lacking and often creates a daunting backlog. With data analysis limitations in mind, we developed a Machine Learning Algorithm (MLA) that can automate morphometric measurements of large whales. The MLA can be taught to recognize a specific object from a background and then provide information on that object. A base network trained in object detection via ImageNet was modified to recognize southern right whales (*Eubalaena australis*) and provide morphometric information on the body shape of an individual whale. The MLA, named 'CetaCon' is able to measure a whale along its central axis from rostrum to fluke notch and width at every pixel along the body axis. With morphometric data on a multitude of individual whales, CetaCon is able to output a population distribution of body shape, with the added ability to compare individual whales to this distribution to determine how they vary from the mean. Distributions from disparate populations can also be compared in order to monitor whale health across temporal and spatial lenses. CetaCon will provide a standard tool with which researchers can easily analyze large amounts of morphometric data in a relatively fast and easy manner. It will not only facilitate the development and validation of methods for rapid assessment of condition, health and demography for southern right whales, but has the potential for modification for cetacean species around the globe.

The contribution of citizen science to the conservation of Mediterranean monk seal (Monachus monachus) population at Madeira archipelago

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Monitoring to assess situations and space-temporary trends is fundamental in biodiversity conservation programs. A particularly powerful tool which plays a fundamental and growing role in the conservation-society-policy relationship is Citizen Science. The society voluntarily participates in conservation projects based on their enthusiasm and concern for environmental problems. In addition to provide important and reliable data, it has the potential to change society's attitudes toward science and the conservation of the planet.

In the case of Mediterranean monk seal conservation at Madeira archipelago, the RED SOS *Lobo Marinho* Network was created under an EU LIFE project, to gather collaboration and data from citizens, willing to provide monk seal observations as well as to warn the competent authority about threats and problematic situations for seals that may need intervention. Collaboration agreements

were established with 22 official institutions, 17 whales watching and diving companies, and 17 private volunteers. A protocol of action, which includes an ethical code of behavior in the presence of seals and a specific RED SOS telephone number, has served to coordinate and homogenize the gathering of information among the participants, including many spontaneous collaborators. Between 2014 and 2018, 686 monk seal sightings have been reported throughout the whole archipelago, 74% from non-official institutions (39% citizens, 18% sports divers and 15% fishermen from coast and fishing sailors, 2% tourists).

Observations reports have contributed with good information about the seals habitat use and with quality images that have been incorporated into the seal identification catalogues. It also provided warnings about seals in difficult situations (mostly animals disturbed by humans or weak) allowing the intervention of authorities in 7 occasions, and allowed the recovery of one carcass for necropsy purposes. RedSOS has proven to be an effective public participation tool for conservation and as an informal educational experience that promotes environmental awareness.

The use of Unmanned Aerial Vehicles (UAVs) to sample small cetaceans blow microbiome.

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Unmanned Aerial Systems (UAVs) are increasingly used for studying and monitoring free ranging cetaceans. These charismatic species are considered by many sentinels of ecosystem and environmental health. Our study focused on assessing a standard non-invasive method for sampling and analyzing cetacean blow samples collected using UAVs.

In order to set sampling and analytical methods, a series of blow samples from 6 bottlenose dolphins (*Tursiops truncatus*) kept under human care at Acquario di Genova were collected using 6-well plates, positioned at different heights over the blowhole. The same sampling kit, assembled on a waterproof UAV, was used to sample wild bottlenose dolphins in the Gulf of Ambracia (Greece) and a sperm whale (*Physeter macrocephalus*) in southern Tyrrhenian Sea (Italy). Samples obtained from wild cetaceans, did not provide a biological matrix for genetic and pathological biochemical studies. Nevertheless, we managed to identify a variety of microorganisms (microbiota) presents in the dolphins' upper respiratory tract by using 16S Illumina Amplicon Sequencing. As expected, the water samples contained more bacterial taxa while those from animals were similar in taxa richness. The composition of the bacterial community differed between the Greek water, wild animals and samples from dolphins under human care.

Although the number of samples used for this study was limited, our results are rather encouraging. Using UAVs to collect exhaled air from small cetaceans is a quite challenging process both logistically and technically. Main difficulties are derived from behavioral differences when compared with larger cetaceans; their fast swimming speed and the unpredictable movements together with short-lasting ventilations, lower blows and dynamic social structure forced us to approach them differently that what to do typically when sampling in whales. Our newly developed tool was clearly proficient in achieving its goal, as supported by the evident microbial differences between sea water and blow samples.

Mediterranean monk seals interactions with fisheries at Madeira archipelago

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Negative interactions with fisheries has been identified as one of the major threats to Mediterranean monk seal conservation along its distribution range. In Madeira, previous studies showed that most fishermen believe that the species does not cause damage and are not accidentally

entangled in fishing gear. This may be caused by the prohibition of fishing nets in the archipelago, and a low overlapping with seals foraging areas, due to the great dependency of this sector on the exploitation of deep-water species, large pelagic migratory fishes and small pelagic fishes. To evaluate this interaction, a program of observers onboard Madeira fishing vessels was developed between 2016 and 2018 with presence on 200 fishing trips of a duration between several hours and 3 days, in 20 different boats from 9 different fishing harbors, using 8 different fishing gears. No interactions with seals was observed, and only in 2 occasions a seal was observed, both from boats fishing with traps just hundreds of meters from the coast. To determine fishermen's attitude towards the seals, interviews were performed to 98 fishermen of 45 different boats, with 24 questions about fishing gear, target species, evolution of captures, current problems for fisheries, and monk seals. 47% of fishermen never observe seals while fishing, 82% think that seals should be in protected areas without fishing, 52% wouldn't like the monk seal population growing, and 2 out of 3 captains consider that monk seals harm fisheries. In general fishermen are afraid of being blamed as the responsible for the monk seal decline.

Current interaction with fisheries is low and restricted to coastal fisheries, but fishermen still have a reluctant attitude towards them, making information and awareness campaigns necessary.

Residency, local movements and potential isolation of the Madagascar Omura's whale population

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Most baleen whales are migratory, with life history patterns and ecological parameters determined by spatiotemporal separation of feeding and breeding. Omura's whales are a species whose range is exclusively tropical/warm temperate, and thus does not engage in long-range latitudinal migration. Here we report multidisciplinary evidence indicating that the population off northwest Madagascar is non-migratory and likely constrained to a restricted, isolated range. Passive acoustic monitoring conducted at four sites across 80km for one year indicated residency of the Omura's whale population in this region; song was present year-round with strong spatial and some temporal heterogeneity. Four satellite-tagged individuals yielded 30 to 58 day-long tracks during November to January, displayed restricted movements along a 405km stretch of continental shelf (mean=283km), and moved multiple times throughout their individual ranges (mean track=2530km). Behavioral switching state-space models indicated highly localized movements (mean b-mode=1.8), involving short periods of transiting between specific areas where the whales displayed localized movements for several days, likely feeding. During directed field surveys, feeding was frequently observed on dense patches of the tropical krill *Pseudeuphausia latifrons*, which appeared episodically following dense blooms of cyanobacteria *Trichodesmium* sp. Photographic re-sights of individuals were evident within and across years, including at least one reproductive female sighted in four of six years from 2012 to 2017, once with a calf, suggesting strong site fidelity. Species distribution models indicated favorable habitat conditions for Omura's whales along the northwest coast of Madagascar, defined primarily by shallow depth and high photosynthetically active radiation, with little other predicted suitable habitat throughout the Southwest Indian Ocean. Combination of these data indicate that this is a resident, non-migratory population whose distribution is likely determined by local, shallow-water ecological processes and patchy, ephemeral prey resources. Furthermore, this population of Omura's whale may be isolated within a fragmented oceanic/global range for the species.

Do male and female sperm whales live separate lives because females outcompete males for the best food?

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Sperm whales are characterized by a complex social system, with groups of females forming long-lasting social units, and males becoming increasingly solitary with age. The evolution of this complexity may have been partly driven by the proximate competition between males and females to access the best food resources. Particularly, females appear to be outcompeting males, which might have forced the latter to explore waters at higher latitudes to support their large size. Even though there is evidence of reduced male feeding success when co-occurring with females, no study has explicitly assessed intra-specific differences in diet that could support this hypothesis. In this study, we aim to compare the diet of female and male sperm whales in the waters around the Balearic Islands, a breeding ground for the IUCN 'Endangered' population of Mediterranean sperm whales, where females and males co-occur but segregate at a fine spatial scale. Dietary differences will be assessed through the analysis of N and C stable isotopes in skin samples, and combined with long-term feeding success and habitat use data to assess the degree of sexual segregation. Analyzing sperm whale diet can elucidate critical aspects of their interactions with conspecifics, the environment, and other species therein, as well as provide important information for their conservation.

Our neighbors the inshore dolphins: A citizen science mark-recapture assessment of urban bottlenose dolphins in La Paz Bay, BCS.

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By the nature of their near-shore distribution, inshore bottlenose dolphins often suffer from adverse effects derived from anthropogenic disturbances such as maritime traffic, fishery interactions and habitat degradation, which take place in the temporal scale in the short to mid-term. In La Paz Bay, these inshore dolphins are sympatric for over six months with whale sharks aggregating at less than a mile from the shoreline, both species represent a very important resource for the local eco-tourism, a key income-sector for La Paz. Effective management and conservation strategies require information regarding their abundance. This assessment estimates the effective population sizes of bottlenose dolphins in La Paz Bay using photo-identification. This case study aims to contribute to the understanding of the processes that influence habitat use of free-ranging populations of inshore dolphins under high levels of anthropogenic pressures due to their almost urban-occurrence. Using boat excursions focusing in both charismatic species as platform of opportunity, photo-Identification data have been gathered since 2015 and processed to construct a history of encounters. Open population models (CJS) were applied to generate Insights in demography (Φ: apparent survival, p: probability-capture) and population size. The best-fitted CJS model was that considering the effect in all population parameters, average survival estimates (0.92; C.I: 0.29-1) and probability of capture (0.25; C.I: 0.09-0.59) are associated with a population size of 79 individuals (C.I: 70-90). This abundance estimate was similar to previous estimations considering 6 years (1989-1994). The core area of distribution for the species is characterized by important biological productivity and low predation risk, which may promote these demographic pattern. However, what could be the critical calving/foraging habitat for this inshore marine predator is encroached by coastal development. Citizen science approaches presents a cost-effective alternative to increase monitoring. A more in depth assessment of behavior and demography is currently underway.

Toward the evidence of male mating strategies in Indo-Pacific bottlenose dolphin populations along the south-west coastline of Western Australia.

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Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) inhabiting the coastal and estuarine waters of Perth, Western Australia, define three socio-geographic resident communities. Their small sizes and individual long-term interactions associated with respective site fidelity would suggest an intra-community complex social structure. This study investigated the presence of male alliances within the Swan Canning Riverpark (SCR) estuarine community, their stability, and access to females. Association indices along with tests for preferred and avoided affiliates were examined using eight years of photo-identification and behavioral data. Two resident adult male alliances (one trio and one pair) were detected from

three parameters: high association indices (SI > 0.79), significant preferred affiliates within alliances, and significant avoidance between alliances (SI < 0.05). Other males were occasionally associated with one of the alliances (SI = 0.37 – 0.21). Males were seen with females in 106 encounters (36%), many of whom (86%) when females were considered to be receptive at that time (i.e., no calf or > 2-year old calf if present). Rare events of what looked like a 'rooster strut' and the annual observation of adult females from the adjacent communities with the SCR male alliances (6% of the encounters) also suggest mating competition, most likely for non-randomly selected females (i.e., eight out of 67 adjacent females including two observed in multiple years). Although both alliances will see a change in the next few years due to loss of affiliates, two resident juveniles showed significant preferred affiliates with a high association index (SI = 0.68) estimated over the last five years, an indication of future alliance formation. However, consistent loss of individuals due to human impacts (i.e., fishing line entanglement) may deflate the benefits for males to form alliances and/or increase the competition level for females if the numbers of SCR resident females decrease.

Sea surface temperature drives narwhals' movements in the Arctic

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Arctic cetaceans are expected to face behavioral adaptations in response to increasing temperatures and sea-ice loss due to climate change. The distribution of the narwhal extending from the Canadian Arctic Archipelago (CAA) to Franz Josef Land (Russia) illustrates the use of contrasting environmental conditions, suggesting a certain degree of behavioral plasticity of this cold-tolerant species. However, the way narwhals will cope with a warming Arctic ocean is poorly documented. The objective of this study was to conduct a comparative analysis of narwhal movements tracked at different summering grounds to (1) assess the Sea Surface Temperature (SST) trend at the summering grounds in relation to (2) their temperature tolerance, in order to (3) anticipate their future hotspots. Between 1993 and 2018, a total of 142 narwhals were satellite-tracked on both sides of Greenland (94 west and 48 east) at three main summering grounds: the CAA, Northwest Greenland (NG) and Southeast Greenland (SG). The use of state-of-the-art ocean models run over a long time-series (20 years) showed a sharp SST increase in NG and SG, whereas no change occurred in the CAA. The largest abundance of narwhals is found in CAA (>100.000), but it is unknown whether increasing temperatures have caused narwhals to leave their low abundance (<5.000 individuals) summering grounds in NG and SG. Additionally, the Generalized Additive Models showed a "dome shaped" relationship between whale density and SST, with a temperature optimum 3°C higher in SG (3°C) compared to NG and CAA (0°C). This result suggests that narwhals from SG could be forced to migrate to new habitats due to an imminent global warming scenario.

Do fin whales avoid noisy area? Analyse of trajectories in relation to shipping noise.

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Western part of the Mediterranean Sea hosts populations of fin whales. Depending on the seasons, the animals are known to be located in the Pelagos Sanctuary (in the Ligurian Sea), and can migrate around Corsica and Balearic Islands. This area is also frequented by several shipping activities: regular ferry lanes, as well as tanker and super-containers of various sizes. These types of boat are major contributor to low frequency ambient noise in the Mediterranean. Such anthropogenic noise can cause masking of the communications of baleen whales, and may lead to the risk of impacts at the population scale.

In this study, the relation between fin whales migration patterns and shipping noise levels is investigated. Positions of animals are retrieved using tagged data. Received levels are computed using AIS and propagation model.

Results are firstly analyzed in terms of masking. Additional behavioral data from the tags, such as speed and cape, and environmental information, such as chlorophyll concentration, provide

preliminary framework for risk assessment and identify suitable management solution for conservation.

Metapopulation dynamics of coastal dolphins through mark-recapture techniques: A case study from southeast China.

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Indo-Pacific humpback dolphins (*Sousa chinensis*) inhabiting the Pearl River Delta (PRD) region, southeast China, are affected by multitude of anthropogenic impacts. Although early research and conservation efforts date back two decades, much of the dolphin population ecology remained poorly understood. We used a multi-year photo-ID dataset collected across the PRD and a suite of modelling techniques to investigate the population socio-demographic structure, connectivity and trend. Manifold quantitative measures indicate that in the PRD, humpback dolphins form a complex metapopulation with socially distinct and spatially discrete subpopulations. Individual site fidelity is weak in the short-term (days/weeks), but moderate-to-strong in the long-term (years). Individual movement across few tens of kilometres is common, across several tens of kilometres infrequent, and across few hundreds of kilometres is unlikely. Although dolphin groups are fluid and inter-individual associations are short-lasting, there is a notable social structure across the region with well-discernible social communities. The spatial ranges of communities are identical to that of subpopulations, and it seems that the ranging/foraging strategies of individuals determine their potential affiliates and hence the broader social dynamics and structure of the PRD metapopulation. Population models indicate that there are ~2000 dolphins in the PRD coastal waters, but their survival rates are well-below the threshold of long-term population persistence. The metapopulation connectivity, albeit low-level, prevents demographic independence of the subpopulations and has an overall stabilising effect on population viability. Even so, however, the metapopulation is declining ~3% annually, more rapidly than previously thought, which corresponds to the IUCN's Critically Endangered status. Local extirpation of any of the subpopulations within PRD, which seems likely according to current population trajectory, may have dire consequences as it will likely trigger major population fragmentation. Consequently, a better understanding of metapopulation dynamics of the PRD dolphins is crucial to any future conservation actions.

More than snacks: An analysis of drone observed blue whale surface lunge feeding linked with prey data.

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To understand how predators optimize foraging strategies, extensive knowledge of predator behavior and prey distribution is needed. Blue whale foraging behavior is primarily driven by krill patch density, but studies have not fully considered surface feeding as a substantial ecological component or significant foraging strategy. Neglect of surface feeding behavior stems from a paradigm that krill density is greater at depth. Yet, we use 90.6 h of echosounder data collected on a blue whale foraging ground in New Zealand to demonstrate that krill density was greater toward the surface (< 20 m). Foraging blue whales (n=15 of 32 sightings) had short dive times (2.59 ± 0.28 min) and used habitat with relatively shallow, dense krill aggregations. These results indicate that blue whales in this region may exploit shallow krill aggregations to minimize energetic costs and oxygen consumption during diving. Additionally, we used an unmanned aerial system to captured unique video of a blue whale's surface feeding behavior on well-illuminated krill patches. Kinematic analysis of the video illustrates the whale's use of vision to target the patches and make foraging decisions, with subsequent biomechanical coordination to maximize prey engulfment. At strike, the whale's mouth begins to open while at maximum speed (3.33 m/s), and reaches its widest gape angle of 33° 1.5 s after strike when maximum upward head pitch (15°) and maximum deceleration (3.7 m s^{-2}) also occur. Surface krill in the target patch (45 m^2) begin to respond 0.8 s pre-strike when the whale is 2 m away, and moving 3 m/s. Understanding how blue whales optimize foraging effort presents logistical challenges, which may cause incomplete sampling and biased ecological knowledge. We conclude that

surface foraging could be an important strategy for blue whales, and integration of UAS with tag-based studies may expand our understanding of their foraging ecology.

Preliminary results of total mercury concentrations along leopard seal whiskers

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With increasing changes to the climate and increasing human presence in Antarctica, efficient tools are required to monitor the health of Antarctic ecosystems. Leopard seals (*Hydrurga leptonyx*) are important top level consumers of diverse prey in the Antarctic Peninsula, with a documented top-down effect on other Antarctic fur seals. With lifetime Antarctic residences, these apex predators should be an ideal sentinel species for tracking the health of the Antarctic Peninsula ecosystem. However, leopard seal diet and contaminant loads have been sparsely studied. In this study, we analyzed leopard seal vibrissae for total mercury (THg) using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Due to a lack of suitable microanalytical standards, results are expressed as ratios of counts of Hg relative to S, the latter of which has been shown to have relatively stable concentrations in other natural keratin- and cuticle-like materials (e.g., hair). Initial results from two adult female whiskers show that Hg/S intensity ratios range between 0.007 and 0.080, with respective means of 0.03 and 0.01. These respective 5-8 year time series suggest that THg concentrations may fluctuate by over an order of magnitude during portions of leopard seal lives. Although preliminary, these data support the prospect of using whisker-based time series to track contaminant loads and diet changes over multi-year intervals. Future analysis will integrate new keratin microanalytical standards for quantifying "true" THg concentrations, in addition to stable C and N isotope analysis to see how seasonal changes in isotope ratios relate to the LA-ICP-MS Hg time series.

How do dolphins communicate their emotions? Potential role of behavioral laterality.

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Behavioral laterality, i.e how specific behaviors are realized using either the left or right side of the body predominantly, reflects the difference between the left and the right hemisphere. In vertebrates' brain, respectively the left hemisphere controls routine tasks, and the right hemisphere emergency responses to unexpected stimuli and expression of intense, negatively connoted emotions as fear. According to this theory, social behaviors should be lateralized. Within their fusion-fission society, dolphins should preferentially use their right pectoral fin/eye to perform and maintain social contacts.

We investigated behavioral laterality in 8 bottlenose dolphins (*Tursiops truncatus*), 2 males and 6 females, during their social interactions. Dolphins were observed twice a day for 20 minutes long each time (n= 66). We recorded the number of times dolphins used their right vs left pectoral and investigated visual laterality by recording the duration each dolphin swam on a conspecific's left or right side.

Results at group level didn't show a significant right pectoral bias during pectoral contact. However, at an individual level, females appeared to be more lateralized than males. One female used significantly more often her left than right pectoral fin and two other females swam respectively more on their partner's right and left side.

Even if laterality at group level didn't emerge, our results show an inter-individual variability. This suggests that individual characteristics as the age, sex or affective state potentially influence visual and motor laterality in cetaceans. One supposed function of pectoral rubbing is to provide informations. Moreover, in our study this behavior frequently occurred after aggressive behaviors in order to gain appeasement. Consequently, we suggest that the preferred use of one pectoral fin depends on social contexts and gives precise information on individual's arousal level. Further studies are required to understand how cetaceans express and communicate their emotions.

30 years of Southern right whale monitoring shows that Australia's major calving ground has reached capacity

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Seasonal trends in the distribution and abundance of southern right whales (SRW) *Eubalaena australis,* were assessed in Australia's largest calving aggregation ground at the Head of the Great Australian Bight, in the Commonwealth Marine Reserve, South Australia. Annual cliff-based surveys were undertaken between June and October from 1992 to 2016. SRW were primarily distributed within a 15 km by 2 km area within the 10 m depth contour (with 95% of whale sightings made within a 10 km^2 area). The distribution of SRW at Head of Bight varied within an individual season but was consistent among the years. The composition of SRW sightings was 70% female-calf pairs and 30% unaccompanied whales. Peak abundance occurred between mid-July and end-August for female-calf pairs and unaccompanied whales (juveniles or adults not accompanied by a calf), earlier than previously reported. A mean of 16% (range=8-28%, SD= 6.5, 95% CI=0.15) of calving females were present at the site in mid-June and a mean of 37% (range=13-61%, SD= 15.8, 95% CI=0.37) remained at the site at the end of September. Based on nearest neighbour distances of 150 m the area occupied by 95% of SRW at Head of Bight reach carrying capacity at 68 female and calf pairs. Results suggest that the primary aggregation area at Head of Bight has reached saturation capacity and that habitat expansion can be expected as the population increases. This study provides information on SRW seasonal trends in distribution and abundance, timing of arrival and departure from the site and peak abundance periods relevant to application to conservation and marine park management. As management requirements increase with a growing population, there is a need to complete an Australia wide assessment of SRW connectivity and habitat expansion.

Man, you smell! A behavioral and chemical assessment of olfactory discrimination in Australian sea lion males.

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A breeding colony of otariids (fur seals and sea lions) can be described by the loud background noise and also by its strong smell. During the breeding season, most otariid adult males develop a strong, highly characteristic musky smell, that the human nose can detect from a long distance. Behavioral observations of Australian sea lions suggest that breeding males are able to detect the presence of other breeding males by raising their rostrum and sniffing the air. To assess if Australian sea lion males can achieve olfactory discrimination during the breeding season, we tested in the field 10 adult males and 6 subadult males with two different scent stimuli: the scent of an adult non-mate guarding male from the colony and a control natural scent (seaweeds). In addition, in 2015 and 2016, we collected general body scents from both adult and subadult males within and without the breeding season in two different colonies for chemical analysis using Gaz Chromatography-Mass Spectrometry (GC-MS). This was to assess differences in body odour production and to identify the chemical compounds involved in this process. We found that males' responses were significantly stronger to male scent than to seaweed scent. Scent samples collected during and outside the breeding season differed significantly in the composition of chemical compounds, and we also found a significant difference in chemical profiles of males from the two distinct breeding colonies. The cause of these differences in males' chemical profiles and the chemical composition of male scents are discussed.

Habitat suitability as a tool to detect spatial and temporal distribution changes of marine mammals

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Modeling distribution change as a consequence of climate change requires confidence in model predictions under novel conditions. However,

models often fail if a proper baseline for comparison is not previously defined. A habitat suitability model for short-beaked common dolphin (*Delphinus delphis*) was developed from dedicated sighting survey data collected by NOAA- NEFSC and SEFSC from 2010 to 2017 in the western North Atlantic. The objectives of this study were: 1) identify the main environmental covariates related to the abundance and distribution, based on generalized additive models to establish their habitat suitability, and 2) identify changes in habitat suitability in response to changes in the environmental covariates that could affect the species distribution. The most parsimonious model included SST, distance to the Gulf Stream north wall, distance to shore, bottom temperature, distance to the 1000m isobaths and latitude, explaining 35.3% of the deviance. For validation, the common dolphin model was applied to the summer 2004 environmental covariates and predicted abundance and habitat suitability of the species. The habitat model estimated abundance was not statistically different than the abundance previously reported for 2004 when corrected for availability bias. In addition, the habitat suitability map matched the common dolphin sightings recorded for the season and year. During the study period clear seasonal changes and interannual variability were detected, especially in the northern range of the species distribution within the study area. The effect of SST on common dolphin habitat suitability is discussed in terms of the mechanisms limiting the species distribution that might differ among geographic regions, or at different times.

Tired eyes no more: Automated image recognition of humpback whale fluke identification surpasses human manual matching.

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We developed and implemented automated image recognition for humpback whale (*Megaptera novaeangliae*) fluke identification that has achieved matching results exceeding what the human eye is capable of. The algorithm was developed through a *Kaggle.com* competition, generating submissions from 2,131 teams matching 5,000 test fluke images to 20,000 identified reference fluke images. The matching accuracy of the top 181 submitting teams was >0.90, while that of the top five winning algorithms was 0.967 to 0.973. We refactored and implemented the most deployable of the winning algorithms into the citizen science and research collaboration platform *Happywhale.com*. Happywhale has built a database of over 25,000 humpback individuals with at least one fluke ID image per individual through collaborating research groups and citizen science contributions; prior to implementation of this algorithm, matching was undertaken through a combination of previous versions of image recognition algorithms, research collaboration and manual matching. Application of the new algorithm to our known whales found 8.6% (2178 of 25195 individuals) as internal duplicates. Found matches included numerous examples of calf to adult matches with greater changes in fluke pattern than human eyes could reasonably detect. The algorithm performed extremely well with poor-quality images and images with minimally featured all-white and all-black flukes, finding many matches in catalogs that have been manually reviewed for decades. 3% of proposed matches could neither be rejected nor confirmed, and many matches could be confirmed as correct only after further image processing and extended review, demonstrating that automated image recognition has surpassed functional manual human image matching. This new algorithm largely eliminates the need for manual matching; it now forms the basis of two broad collaborative studies of humpback whale migratory patterns and population dynamics across the North Pacific and South Pacific, studies on a scale that would be intractable without effective automated image recognition.

Non-song calls produced by a female humpback whale (Megaptera novaeangliae) in Hawaii

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Recently there has been increased interest in non-song vocalizations produced by humpback whales in the quest to understand humpback whale behavior and communication. However, these sounds are still relatively poorly studied in many group types, locations, and from the different sexes. Here we present the first known calls from a juvenile female humpback whale and contrast these with calls from adult dyad groups as well as calls in mother-calf groups recorded in waters off Maui during the breeding season. An Acousonde suction cup acoustic recording and data logging tag, sampling acoustics at 10 kHz and other sensors at 5 to 800 Hz, was deployed on the juvenile female as well as whales in the others group types. Three dyad groups were tagged in March 2016 for a total of approximately 12 hours, and 3 calves and 7 mothers were tagged March 2014-2016 for 44

hours. All were focal followed to record behaviors from the surface in conjunction with acoustic recordings. The juvenile female was tagged March, 17 2015. During the approximately 2.5 hours the tag recorded, the female did not approach any other whales closer than approximately 100 m. Consequently, all calls are believed to be produced by the female. From the acoustic data, 129 calls were recorded. The calls were primarily short (ca. < 0.1 sec) and resembled previously recorded non-song calls from mother-calf groups. Calls tended to be grouped together in bouts separated by periods of silence, like other non-song calls. However, calls were produced at a relatively high rate at almost 52 calls per hour, more frequent than mother-calf and dyad groups. Lone female encounters are rare in the breeding areas and this recording provided a unique opportunity to learn about the vocal development of female humpback whales.

Occurrence and feeding activities of Edeni's whale, Balaenoptera edeni, in the northern Beibu Gulf, China

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Stranding records of Eden's whales range from the Yangtze River Estuary to the northern Beibu Gulf, including the Taiwanese coast, but information about the distribution, habitat use and population status of the Eden's whales in Chinese waters is limited, and there have been no live observations, particularly in inshore waters along the Chinese coast. According to the Eden's whale occurrence and feeding sites identifying that based on citizen science information from collaborative fishermen, LEK baselines from questionnaire interviews and records from opportunistic surveys, it provides preliminary knowledge of the Eden's whale in the waters around Weizhou and Xieyang Islands before conducting the systematically-designed field surveys. Eden's whale activities including the occurrence and trap-feeding have been recorded by local fishermen since 2016 and from the field trips by the Beibu Gulf marine mammals joint research group which was established in 2016 conducted in May 2017 and April 2018. Questionnaire results also indicated apparent seasonal activities of Eden's whale in the study region. In March and April, trap-feeding activities become the highest. Eden's whales primarily feed on schooling fishes, likely pelagic-neritic anchovy, shad, and sardine. Eden's whale occurrence in the waters between Weizhou and Xieyang Island may associate with annually periodic activities of their preys. This possibility needs further investigation.

Studying call types and sub-call types of Killer Whales in complex and non-stationary acoustic environment using Deep Learning: A data-driven approach.

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Variations of bioacoustic signals pose challenges to categorize calls into classes, subunits, and call series in animal communication research, especially for large datasets. Deep learning methods, together with increasing usage of passive acoustic monitoring, stimulate growing interest in automatic detection and classification. This pilot study demonstrates how to use deep learning to access a large amount of vocalizations of killer whales (*Orcinus orca*) and how to use unsupervised clustering to detect different types of calls and sub-call types.

A deep learning-based segmentation tool with 95% accuracy, was previously trained on noise and vocalizations of Northern Resident Killer Whales (NRKW). A Convolutional Autoencoder, a deep neural network architecture, was pretrained to learn features that best represent NRKW discrete calls, whistles, echolocation clicks, and noises. It is achieved by mapping a given input x to output/reconstruction r via hidden representation h. The call type classifier, using the encoder part of the Convolutional Autoencoder for weight initialization, achieved 96% accuracy in a previous study.

In this study, vocalizations of A30 and A34, two NRKW matrilines, were extracted from 36 hours of archived recordings. Spectral clustering was used to cluster segmented vocalizations from A30 and A34 separately based on autoencoder features. Gap statistic was used to estimate optimal number of clusters. Each cluster was visually (on spectrograms) and aurally examined. Four A30

clusters and two A34 clusters with high homogeneity were matched to discrete call types according to Ford call catalog. By further clustering these clusters, subcall types were identified, which were not referenced in the call catalog. This pilot study shows a promising possibility of using data-driven methods to access large amounts of vocalizations, and to identify subtle structural differences between similar appearing signals. This enables to study variations of vocalizations without or with limited prior assumptions and improves the efficiency of annotation work.

From small cetaceans to the great whales of the east

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The lack of species baseline knowledge is often the principal barrier to conservation, especially if the species of concern are under a wide range of human pressures that are difficult to control or regulate. While the Western Mediterranean Sea has attracted a relatively high level of research, baseline information remains low in the Eastern Mediterranean. This project aims to fill the knowledge gaps on sperm whales *(Physeter macrocephalus)*, Cuvier's beaked whales *(Ziphius cavirostris)* and delphinidae in Turkish Mediterranean waters. The surveys have been conducted over four seasons between April 2018 and April 2019, with 32 days (420 hours) of acoustic and visual effort, covering 3732 km from the Eastern Hellenic Trench to the Anamur. While bottlenose dolphins *(Tursiops truncatus)* and delphinidae species (38 groups) were detected in 21 and 38 encounters, Cuvier's beaked whales and sperm whales were recorded in 2 and 11 encounters, respectively. Bottlenose dolphins and delphinidae species were detected from coastal waters to 3,500m depth. Dolphins detected acoustically in each season with increased activity at night, their visual recordings were highest during spring and summer. Acoustic analysis shows a prevalence of 33 kHz click frequency. Acoustic detections of beaked whales were in 1000m and 3500m contours of the eastern Hellenic Trench in spring and summer 2018. Sperm whale sightings were concentrated on the 1000m contour, but ranged from 500m to 3000m depths, between the Eastern Hellenic Trench to Kekova. The sightings were highest in summer followed by spring and a single acoustic recording in autumn. Photo-identification data of sperm whales revealed a presence of five male and one possible female with a juvenile. The current research is identifying potentially important marine mammal area(s) and underlines the importance of local research effort for collecting the necessary data in the Eastern Mediterranean.

Whisker stable isotope values indicate long-term foraging strategies for female New Zealand sea lions

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Determining the foraging strategies for top marine predators is fundamental to

understanding their role in the marine ecosystem and essential to gain insight into how species

and populations may respond to environmental variability and human impacts. The long-term foraging

strategies of individuals can be studied using stable isotope analysis of whiskers, which

archive keratinous tissue. Here, stable isotope analysis (δ13C and δ15N) along the length of

whiskers from female New Zealand (NZ) sea lions Phocarctos hookeri was used to investigate

individuals' long-term foraging strategies. Previous telemetry studies showed that individual

female NZ sea lions have one of 2 distinct foraging strategies that are habitual within and between

years. Furthermore, past stable isotope research showed that these 2 distinct foraging strategies,

i.e. benthic (foraging on the sea floor) or mesopelagic (foraging at various depths in the water column),

can be identified through δ13C and δ15N stable isotope values from blood and whiskers. In

the present study, chronological serial stable isotope sampling of female NZ sea lion whiskers confirmed

long-term consistency of individual foraging strategies. Thirty-one of 35 individuals

showed constant benthic (n = 13) or mesopelagic (n = 18) isotopic values along the length of their

whiskers. The remaining 4 individuals showed mesopelagic foraging strategies but with slight

oscillations. Serial stable isotope analysis of whiskers is a powerful tool for investigating the ecological

niche of top marine predators throughout their adult life. This tool can be used within the

Auckland Islands' NZ sea lion population to determine the proportion of the female population

that are exposed to detrimental interactions with fisheries.

Can beluga exposure to shipping noise be reduced despite a traffic increase? An individual-based model to inform a noise abatement process in the St. Lawrence estuary and the Saguenay River.

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In the context of the Quebec Maritime Strategy, several port-industrial complexes could be developed nearby or within the critical summer habitat of the endangered St. Lawrence Estuary (SLE) beluga population. In the absence of efficient noise abatement measures, the traffic increase associated with the planned development projects would increase belugas' cumulative exposure to shipping noise. A chronic exposure to noise is a recognized stressor, that might play a role in the current decline of the population. Any increase of anthropogenic pressure could lower even more their chance of recovery. In this context, the Government of Quebec funded a research program led by Université du Québec en Outaouais to assess the potential impacts of port-industrial development projects and explore and recommend noise reduction options in collaboration with multiple stakeholders.

This interdisciplinary research program first focuses on improving a prototype of an individual-based simulation model for beluga and vessel movements coupled with models of underwater sound sources and propagation. This simulation model will be used to assess and compare realistic scenarios of navigation noise abatement co-developed by a multi-stakeholder working group. The research program is tied in with other scientific efforts including some conducted under the Canadian Ocean Protection Plan. The research program will also propose an economic framework of the noise abatement options based on their costs and benefits. This study will provide stakeholders, including the Government and the maritime industry, with tools for decision-making and ways of reducing shipping acoustic footprint.

First, we will present the global approach to 1) cumulative noise impact assessment of navigation on SLE beluga and 2) noise abatement options co-development and recommendation process. We will then describe the main modules of the simulation model with a focus on describing the vessel and whale movement sub-models, and acoustic model. The simulation plan will finally be discussed.

True's beaked whale: A cryptic species revealed.

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Beaked whales are among the least understood families of cetaceans, with many species known only from stranded specimens or a few live sightings. True's beaked whale (*Mesoplodon mirus*) was described in 1913 based on a stranding in North Carolina, but until recently, live animals were only rarely identified. In 2017, we initiated a study of the ecology of deep-diving cetaceans in the shelf break region of Georges Bank in the western North Atlantic, initially focusing on True's beaked whales. This multidisciplinary study integrates visual and passive acoustic monitoring, genetic sampling, and the collection of dive data via a digital acoustic recording tag (DTAG). Between 2017 and 2018, two large vessel surveys covered over 5900km. Small boat work was conducted around beaked whales on 8 days for collection of photo-IDs, biopsy samples, seawater for environmental (e)DNA and deployment of DTAGs. True's beaked whales were sighted over 250 times, comprised of approximately 80 groups. Focal follow data were collected from 10 groups, providing description of surface and dive intervals over periods of up to 9hr. Over 350 acoustic events from the towed hydrophone array were classified as likely True's beaked whale. Species identity was confirmed by biopsy samples and eDNA barcoding, allowing confident descriptions of echolocation click characteristics and external appearance. A DTAG was deployed for 12hr on one individual in a group of five, documenting 9 foraging dives with a mean maximum depth of 1037m (sd 89.6m) and a mean duration of 32.7min (sd 4.2min). Seafloor depth in the area of foraging was over 2000m, indicating exploitation of mesopelagic prey. Cuvier's beaked whales were frequently sighted and acoustically detected in proximity to True's. Results of this study will provide much needed data for identifying True's beaked whale in the field, as well as describe the ecology of this cryptic, understudied species.

Distribution and occurrence of large whales in New York Bight prior to 2017: Establishing baselines and informing management.

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The New York Bight is one of the busiest waterways in the world, where industries such as shipping, tourism, fishing and renewable energy development coincide with a diversity of marine wildlife. Large whales have been sighted with increasing frequency in recent years, yet detailed information on species distribution, required for effective management and planning, remains scarce. With growing conservation concerns, a synthesis of large whale sightings data from 1998 to 2017, including published and unpublished data, was conducted. MaxEnt species distribution models were constructed for two commonly sighted species: fin and humpback whales. A total of 221 fin and 225 humpback whale sightings were used in the analysis. Bathymetry, distance to shore, slope of the seafloor, sea surface temperature, chlorophyll-a concentration and zooplankton biomass were included as covariates. Zooplankton data, a proxy for foraging potential, were only available for waters within the 200m isobath, thus two models were run for each species: the first included all covariates for waters less than 200m; the second included all covariates except the zooplankton data for the entire study extent. Areas with high probability of presence were largely coastal in both fin whale models, with low probability of presence past 200m. Humpback whale models identified high probability of presence near New York Harbor and areas along the 200m isobath. Distance to shore and

chlorophyll-a concentration contributed most to fin and humpback whale models, respectively. Inclusion of zooplankton data appeared to influence the probable distribution of both species as a result of patches of relatively high zooplankton biomass. Results also highlighted areas of anthropogenic overlap with whale occurrence, including potential offshore wind energy areas. These results provide valuable baselines to inform future research and monitoring efforts, and the development of best management mitigation practices that may minimize impacts to whales in the New York Bight.

Estimating body mass of free-living whales using non-invasive aerial photogrammetry and 3D volumetrics.

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Body mass is a key life history trait in animals, determining metabolic rates, food requirements and fasting endurance. Despite being the largest animals on the planet, no method currently exists to estimate body mass of free-living whales. We provide a non-invasive method to accurately estimate body mass of right whales (*Eubalaena sp.*) while accounting for both their structural size (body length) and relative body condition (body width). First, aerial photogrammetry from unmanned aerial vehicles was used to measure the body length, width (lateral distance) and height (dorso-ventral distance) of free-living southern right whales (*E. australis*; 48 calves, 7 juveniles and 31 lactating females) in Península Valdés, Argentina. From these data, body volume was estimated by modelling the whales as a series of infinitely small ellipses. Compared to a circular cross-sectional model, our elliptical model improved volume estimates by 23.6% (mean=6.1%, SD=5.3). The body girth of the whales was next calculated at three measurement sites (across the pectoral fin, the umbilicus and the anus) and a linear model was developed to predict body volume from the body girth and length data. This model was then used to estimate the body volume of eight lethally caught North Pacific right whales (*E. japonica*), for which body mass was measured. Using the predicted volume and known mass of the lethally caught whales, we then calculated a volume-to-mass conversion factor of 755kg m^{-3} (SD=50). This conversion factor was consequently used to predict the body mass of the free-living whales from Argentina. Our body mass model predictions were accurate to within 5.7% (mean=1.6%, SD=0.01) of estimated mass, which is six times higher than a simple body length-to-mass model. Our modelling approach opens up new avenues to incorporate allometric relationships of body mass into studies of large whale bioenergetics and ecophysiology.

Genetic structure as revealed by mtDNA and Microsatellites in Northern Fur Seals, Callorhinus ursinus

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The Northern Fur Seal is a widely distributed philopatric species that breeds on a limited number of islands across the North Pacific Ocean. Recently, the number of individuals on breeding islands in Alaska has been decreasing, but in Russia it has been increasing. Furthermore, on the coast of Hokkaido Japan, reports of fishery damage from this species are increasing. For management and conservation of this species, it is necessary to clarify whether population structure exists. Due to differences in population dynamics among breeding islands, and because many individuals are philopatric (Baker et al. 1995), the species can be classified as two subpopulations as Russian and Alaska. However, previous studies were unable to find population structure in the northern fur seal (Dickerson et al. 2010). The aim of this study is to clarify the presence or absence of population structure using new polymorphic makers. We investigate the genetic variation of northern fur seal among breeding islands, using 432 individuals from nine islands (each n=48). To test for genetic variability and population differentiation among islands, 13 microsatellite loci, 295 bp from the mtDNA control region and 1198 bp from the mtDNA cyt-b region were used. In mtDNA, consensus sequences from all samples were aligned in MEGA7. Population structure among population groupings was performed in Arlequin3.5 and PopART1.7 was used to create network diagram. In

microsatellite loci, polymorphism was detected with GENEPOP and Arlequin3.5 was used to compute unbiased estimates of F_{ST}. The most likely number of populations (K) was estimated using STRUCTURE2.3.4 and DAPC analysis. In total, we identified 220 different haplotypes in the control region and 173 different haplotypes in the cyt-b region. In 13 microsatellite loci, F_{ST} suggested population structure between some Russian and Alaskan populations. STRUCTURE analysis estimated that K=1, but the DAPC analysis estimated that K=2.

AgentSeal: Movement of harbour seals: an individual-based modelling framework as a reliable management tool to study multiple stressors.

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Marine environments are threatened by human exploitation, degradation, construction and operation of offshore structures. Such environmental changes can strongly influence behaviour and performance of individuals e.g. foraging, breeding success. Design of a reliable tool which can predict long-term consequences of a combination of stressors on animal movement and population dynamics is important, especially to allow regulators, developers and NGOs to make 'what if' scenario predictions.

We present results of an individual-based model (IBM) for harbour seals, a species showing recent declines in parts of the UK. The IBM simulates movements of harbour seals according to realistic decision rules. Model outputs include the predicted spatio-temporal distribution of the animals and their energetic status and can be used to predict simultaneous and cumulative effects of different stressors at individual and population level. This is the first seal IBM which includes dynamic processes such as changes in food availability and bioenergetic needs of animals.

The model structure and parameterisation is based on observations and data collected over 20 years by SMRU including telemetry data from 300 animals, annual survey counts, bio-energetics and physiology, and behavioural observations. Results from the first phase of modelling represent seals along East Scotland, simulated in 15 min time steps over 1 month of foraging.

This model successfully reproduces bioenergetics, movement at various scales: fine- (step length and turning angle) and large-scale (trip duration and extent, spatial distribution); and daily activity budget. It also reveals that mechanisms related to prey digestion determine energetic and activity budget of seals and that underlying prey abundance and distribution is a crucial element of the model.

Further phases of modelling will extend these investigations to take account of annual movement including breeding, moulting and migration; simulation of the effect of multiple stressors on movement and population dynamics of seals.

Extreme synchrony in diving behavior of Cuvier's beaked whales (Ziphius cavirostris) off Cape Hatteras, North Carolina.

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Cuvier's beaked whales are sensitive to certain anthropogenic noises, but we understand very little about how sociality mediates their behavioral responses to disturbance. Studies of the social behavior of this species are challenging because of their pelagic distribution and the limited time they are available to observe at the surface. Only adult males have erupted teeth and high levels of scarring suggest that males compete agonistically for access to females. We predicted that associations among adult males would be unstable over time and tested this prediction by evaluating the diving behavior of pairs of animals instrumented in the same group with satellite-linked depth-recording tags off Cape Hatteras, USA. We used diving records and a null model to determine if dyads tagged together dive more synchronously than expected by chance. We found that adult male-male dyads (n = 4) showed extended periods of diving synchrony, with 77-89% of the beginnings and ends of each long dive (>33 min; usually >800 meters) occurring within 60 seconds of each other. This synchrony persisted

from 6 to 17 days. All dyads that included an adult male with a different age sex class individual (n = 4) dove synchronously for less than a day. Higher resolution data on one male dyad showed synchrony in both short and long dives, and visual observations over multiple days suggested that the two males remained together in the same group. We explored several explanations for these surprising results, including cooperative foraging, predator defense, extended competitive bouts, and the existence of male-male alliances. We argue that male-male alliances are the most likely explanation for these observations and describe further work we are engaged in to characterize the longer-term fission-fusion dynamics of groups and to determine the duration of these putative alliances.

Site fidelity of Delphinus delphis by photo-identification technique in Samos Island (Eastern Mediterranean Sea)

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Although several local populations were observed within the Mediterranean Sea, the short-beaked common dolphin (*Delphinus delphis*) is ranked as Endangered by IUCN due to its sharp decline during the last decades. Conservation actions to fulfil targets under the range of several international agreements and limit potential threats on this species require robust information on its site fidelity, residency patterns and habitat use. Particularly, identifying critical habitats for *D. delphis* seems to be the first step towards the establishment of an effective conservation strategy within the Eastern Mediterranean Sea. Therefore, a monitoring study on *D. delphis* based on photo-identification data was carried out in Samos Island, providing a knowledge contribution for the Eastern Aegean Sea.

Systematic cetacean surveys and sightings data were collected from February 2016 to July 2018. Individual photo-identification was performed based on a combination of long-term natural marks and dorsal fin pigmentation patterns. The site fidelity rate and the long-term residency pattern were estimated for the photo-identified individuals.

Through the study period, an effort of 164 surveys with 8200 km covered were applied, obtaining 86 sightings of *D. delphis*. Photo-identification data were collected in 38 sightings, providing 73 individuals distinctly identified. The occurrence of re-sighted individuals was up to 6 times as well as of multi-year resident dolphins, providing the evidence that *D. delphis* showed varied degrees of site fidelity in the study area. Results suggest the southern waters of Samos Island as a crucial habitat for the continuous presence of the species. However, a long-term research with wider survey coverage have a critical importance in the identification of a larger *D. delphis* population which will help to understand the currently unknown migration patterns and habitat use of the species within the Eastern Mediterranean Sea.

Declining winter sea ice is associated with a northward shift of bowhead whale winter range.

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Since the winter of 2016/17, unprecedented declines in the extent of winter sea ice have occurred in the Bering Sea. These declines resulted in the primary wintering area of Bering-Chukchi-Beaufort (BCB) bowhead whales (*Balaena mysticetus*) becoming ice-free. As a result, it was

unknown if whales would use their traditional wintering area or shift their distribution northwards to continue to winter under sea ice. Data from satellite transmitters were used to compare the winter (January-March) distribution and dive behavior before the decline in Bering Sea ice (n=28 whales, 2009-2016) and after (n=4 whales, 2018; n=4 whales, 2019). During 2009-2016, whales primarily wintered south of St. Lawrence Island (~62.5° North latitude). In both 2018 and 2019, whales remained north of the southern ice margin, shifting northward ~540 km (into the Chukchi Sea) in 2018 and ~220 km in 2019 when ice extent was greater. The proportion of square- and U-shaped dives, thought to be associated with feeding, did not change with the shift in winter distribution (~90% of all dives). The average percentage of time whales spent at or near the seafloor, however, was less during the winters of 2018 (21%) and 2019 (16%) than during 2008-2016 (30%). These data suggest whales were feeding in the northern wintering areas, but targeting different depths. Bowhead whales wintering north of the ice margin may relate to killer whale avoidance and be less linked to their preference to associate with ice. Bowhead whales associate with ice-free waters in summer, however, killer whales are rarely observed in the BCB bowhead summer range. We are analyzing data from BCB bowhead whales harvested by Alaska Natives to determine if changes in winter distribution and foraging behavior have altered body condition.

Estimating age at weaning for Pacific walruses using trace elements in teeth.

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In mammals, the age at which a mother weans her young is directly related to the amount of energy she invests in that offspring. Thus, weaning age can be indicative of the health and nutritional status of the mother, the availability of resources in the environment, and sex-related differences in maternal investment. Recently, a technique has emerged to estimate weaning age using strontium (Sr) and barium (Ba) concentrations in teeth. Though successfully applied to a number of terrestrial mammals, this method has not been used for marine mammals. The aims of this study were to examine Sr and Ba concentrations in Pacific walrus (n = 118) tooth cementum to determine whether a weaning signal exists and, if yes, to estimate weaning age for female (n = 92) and male (n = 26) walruses. For most individuals, the weaning signal was recorded as a steep decline in Sr (from ~400 to ~250 ppm) and Ba (from ~12 to ~2 ppm); however, this signal was detectable in more teeth for Sr (~93%) than Ba (~80%). Estimates from both elements typically agreed closely, with a mean difference of 0.1 years (Sr estimate – Ba estimate) for males and females. The median estimated age at weaning was three years for both sexes, with ~37% of walruses weaning by age two, ~81% by age three, and ~97% by age four. These estimates compare reasonably well with the relatively sparse literature values, though they suggest that the average weaning age may be slightly later than previously believed. Estimated weaning age did not vary with year of birth (1914 – 2002), indicating that environmental conditions, food availability, and population density are not important drivers of weaning age in walruses. These results demonstrate the potential value of this approach for studying lactation duration and weaning in marine mammals.

Seafloor geomorphic data predictors or bathymetric proxies? An alternative approach into modelling distribution of cetaceans.

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Seafloor geomorphic features, such as submarine canyons, continental shelves, continental slopes or seamounts, have been rarely attempted in modelling as explanatory variables, and when they have been used, usually focus on specific geomorphic features. Despite some attempts to provide more defined identification methods of geomorphic features in research, the prevalence of such identification remains arbitrary. Currently, a global seafloor geomorphic features dataset is accessible, with an objective identification and full representation for each seafloor geomorphic feature. The sperm whale (*Physeter macrocephalus*) and the striped dolphin (*Stenella coeruleoalba)* are two common species in the Mediterranean Sea, with different foraging strategies and relationships with seafloor features. Therefore, these species can provide an understanding of how the use of seafloor geomorphic features into modelling are related with two distinct cetacean-habitat relationships. A standardized ensemble species distribution model (SDM) framework was selected to model the performance of models based on common bathymetric parameters with models based on a distance metric of seafloor geomorphic features,

combined with occurrence data of these two cetacean species. The models shows significant high and low preference for certain seafloor geomorphic regions, or their surroundings. Additionally, our study shows that according to species and modelling technique the model's performance can be improved with the consideration of geomorphic data in comparison with the use of common bathymetric proxies. To our knowledge, this study was the first attempt to use these data as explanatory variables into habitat modelling. We argue that the use of these geomorphic features data as explanatory variables in modelling is providing enhanced insights on the relationship of cetacean species with seafloor regions, and has high potential to improve modelling performance as compared to models commonly limited to the use of bathymetric proxy parameters only.

The latest findings on cetacean welfare in captivity (and how it links to wild research and conservation)

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Animal welfare can be assessed scientifically has recently made the transition from the farm industry to zoos and aquariums. For the past several decades the public display of captive cetaceans has led to controversy due to concerns over the animals' well-being, but which up until recently had not been studied obejctively. In the last few years such research has exponentially increased around the world, mostly on bottlenose dolphins (*Tursiops truncatus*), and this presentation reviews and collates the first animal-based indicators for cetacean welfare in general. Cognitive bias testing has proved a valuable tool, showing that affiliative behaviour (synchronous swimming) is linked to positive welfare states. A certain level of anticipatory behaviour (i.e. preparing for a predictable event) is likely to reflect positive states, but at excessive and sustained levels could indicate poor welfare. Lower frequencies and durations of play suggest negative states in cetaceans, since such parameters decrease following environmental or social stressors. Strong support is given for other potential indicators such as cortisol measurement, Body Condition Scoring (BCS), qualitative ratings of behaviour, and general health parameters. But is any of this relevant to wild cetacean research and conservation? Although perhaps not obvious at first, there are several crossovers between welfare science and conservation biology that have recently been higlighted in the literature, since both focus on the animal's holistic response to environment. Researchers are now suggesting that sometimes an 'individual animal' approach is more effective than population-level conservation, since changes in the environment will affect individuals differently. Furthermore, the rapid and irrevocable decline of some cetacean populations is leading to consideration of *ex situ* conservation options (e.g. VaquitaCPR). Increased collaboration between wild and captive cetacean researchers, and integration of welfare principles into conservation strategy, may significantly enhance our collective understanding of the impacts of environmental change on these animals.

Development of a novel drone-based method to survey marine megafauna at local spatial scales. Lessons learnt from a dugong drone survey in the Pilbara, Western Australia.

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Unlike manned aircraft, drones provide the opportunity to conduct safe, rapid and cheap local-scale aerial surveys of marine megafauna. Nonetheless, surveying at the local-scale using drones and aerial imagery requires us to re-think aerial survey concepts to develop methods adapted to this new technology. In this study, we revisited the fundamental steps of aerial survey methods from design and data collection through to analysis, with the aim of assessing the distribution and habitat use of dugongs in local remote waters of the Pilbara, Australia. We used two types of aircrafts: a vertical-take-off-landing fixed-wing (hereafter fixed-wing) and an off-the-shelf multirotor drone (hereafter multirotor). The surveys were conducted from a live-aboard boat over four field trips. The fixed-wing was flown outside standard operating conditions (i.e. beyond visual line of sight and up to 800ft above ground level) following a traditional line transect design with the aim of surveying a 100km^2 area. The multirotor was flown in a grid sampling design compliant with Australian standard operating conditions (i.e. within visual line of sight and not beyond 400ft above ground level) to survey a 35km^2 area. Overall, we conducted over 390 flights (130 hours), collecting over 89000 images, 191 of which contained dugongs. Limitations in the systems (e.g. manufacturing system failure, wind limits for safe operations) led us to refine our survey protocols to

ensure that they were robust. We developed user-friendly software and protocols to manually review the images, map the image footprints and animal sightings in GIS, and model the dugong distribution and relative density in near real-time during the fieldtrip. This new method can be adapted to any species of marine megafauna and become a very powerful cost-effective tool in the context of local-scale studies such as environmental impact assessment projects and to help the conservation and management of endangered species.

Spatial, temporal, and individual-level variation in northern Gulf of Mexico common bottlenose dolphin (Tursiops truncatus) diet

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Ecological factors that change over spatial and temporal scales may drive dietary variation of generalist foragers at both population and individual levels. Using stable isotopes from skin samples, we examined the diets of common bottlenose dolphins*(Tursiops truncatus)*captured in 2018 at two field sites in the northern Gulf of Mexico: Mobile Bay, Alabama (MB) and Barataria Bay, Louisiana (BB). We examined in detail temporal (2011 – 2018) and individual-level dietary variation in Mobile Bay using isotopes from liver, muscle, and skin. To provide further insight into individual-level variation in isotopic signatures, we also satellite-tracked 18 tagged dolphins in MB in 2018. In 2018, dolphins from both field sites fed primarily on fish (MB 74%; BB 91%), with smaller amounts of decapods (MB 18%; BB 7%) and, in MB only, cephalopods (9%). In 2011, dolphins in MB fed primarily on cephalopods (liver 67%, muscle 48%, and skin 55%), particularly in weeks prior to sampling. Fish were the dominant prey group in all other years, while cephalopods likely comprised < 20% of dolphin diets in those years. The difference in diets between 2011 and other years suggests potential interannual variation in the availability of prey groups, particularly squid. We found considerable among-individual variation in carbon isotope values despite diet similarity, suggesting different foraging habitats rather than prey groups. Data from the satellite-tracked dolphins confirm that among-individual variation in diet maybe related to fine-scale movement patterns in MB dolphins. By comparing long-term stable isotope data from common bottlenose dolphins, and incorporating movement data, we found that dolphins are capable of considerable dietary flexibility while maintaining relatively small ranges.

Diving behavior of humpback whales (Megaptera novaeangliae) in the western South Atlantic Ocean

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Humpback whale (*Megaptera novaeangliae*) diving behavior are relatively well studied in feeding areas (FAs), but information from breeding (BAs) and migratory (MAs) habitats is not as well known. Here we describe the diving behavior of 19 females with calves and 9 males tagged with archival satellite tags deployed in wintering grounds of the coast of Brazil prior to the whale's migration to their feeding destinations. Tag data (mean duration=43 days, range=3-127) yielded a total of 74,059 dives, which were typically shallow (<180m, 98.7%). The distribution among areas was: FA (25.3%); BA (34.3%), and MA (40.4%), with males showing higher frequency of shallow dives than females only in FA. Proportion of deep dives (>180m) was: BAs (2.1%); FAs (32.3%), and MAs (65.5%), with similar frequency between females and males in BAs, higher frequency of females in MAs and higher frequency of males in FAs. Overall, dive depth in the BA averaged 28.3m (range = 1.5-236m) while mean duration was 4.07min (range = 0.1-26min). Females performed relatively shallower and shorter dives (27.1m and 3.78min, respectively) than males (29.23m and 4.72min). In MAs, mean depth and duration were 40.6m (1.5-

464m) and 3.92min (0.1-30.6min), with no obvious difference between females and males in depth (40.1m vs 41.2m) but slightly longer durations for males (4.38min vs 3.60min). In the FAs, mean dive depth and duration were 42m (10-320m) and 2.89min (0.26-30.2min) with females slightly shallow and shorter dives observed for females (37.14m and 2.74min) when compared to males (43.03m and 2.92min). Dive shape frequency was 7.6% for V-shape (mean depth = 41m), 41.6% for square-shape (mean depth = 33m) and 50.8% for U-shape (mean depth= 44.4m). There is evidence that foraging dives occurred during the migration suggesting that animals may be feeding more often than previously thought during this phase of their life cycle.

Ships do not comply with voluntary whale protection measures in Northeast USA waters

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Ship strikes are a major source of mortality for whales worldwide. Slowing ships to ten knots or less can reduce the likelihood of strikes that result in whale fatality. But getting ships to slow down requires overcoming challenges in both communicating conservation measures and convincing ship operators to reduce speed. On the east coast of the USA, ships are required to slow down in seasonal protection zones for endangered North Atlantic right whales (*Eubalaena glacialis*). When aggregations of right whales occur outside of seasonal protection zones, temporary zones are established and ships are asked to voluntarily avoid the area or reduce speed. In November 2018, aerial surveys found an aggregation of right whales in close proximity to one of the New York shipping lanes and outside of any seasonal protection zone. A temporary Dynamic Management Area (DMA) was established and the request that ships reduce speed was broadcast on marine radio as part of a standard US Coast Guard Notice to Mariners. The aggregation persisted into April 2019 as did the broadcasts. In March, the Coast Guard conducted a 'pulse' operation in which ships >300gt approaching the DMA faster than ten knots were contacted directly and asked to voluntarily slow down to ten knots or less when transiting the DMA. We used Automatic Identification System (AIS) data to measure ships' average speed through the DMA for two weeks prior to the operation, for the week-long pulse operation, and for two weeks following it. The distance-weighted average ship speed for these three periods was 12.5, 13.4, and 13.9 knots, respectively. The lack of detectable change in ships' speed despite direct communication to operators demonstrates that conservation measures without consequence were not effective in this case study.

The Pelagos effect: Changes in cetacean distribution over 15 years along a Fix Linear Transect in the Pelagos Sanctuary.

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The Pelagos Sanctuary has been established in north Western Mediterranean Sea in 2004, considering the higher abundance of cetaceans, and especially fin whales (*Balaenoptera physalus*) and striped dolphins (*Stenella coeruleoalba*), in the area. In order to investigate changes over time in cetacean distribution and assess possible positive effect of the creation of the sanctuary, we compared cetacean relative abundance along a fixed transect over 15 years. Pre-Sanctuary assessment was based on Laran and Drouolt-Dulau (2007) based on the 2001-2003 years, while for post-Sanctuary analysis we used data collected from 2016-2019 along the same fixed transect. These data were collected within the FLT MED MonNet project. The most frequently encountered species were the fin whale representing 49% of all sightings with 210 individuals, then the striped dolphin with 42% and 1576 individuals. The relative abundance of striped dolphins increases constantly from June to August 2016 -2019, ($3.1x10^{-1}$ ind.km^{-1}), contrary to what observed in pre-Sanctuary assessment, when two peaks, in May and September where observed (>1.3×10^{-2} ind.km^{-1}). For winter, we observed a peak in November ($3.2x10^{-1}$ ind.km^{-1}) with a minimum value in January, while a consistent minimum value (<0.6×10^{-2} ind.km^{-1}) was obtained from December to April in 2001-2003. Concerning fin whales, while summer relative abundance is similar in the two considered periods, both showing a peak in August with 5.6×10^{-2} ind.km^{-1} and $4.56x10^{-2}$

ind.km^{-1} respectively for pre and post Sanctuary, strong differences occur for winter. While relative abundance was almost zero from November to January 2001-2003, we observed constant presence of the species with an intense peak in January with 5.69x10^{-2} ind.km^{-1}. In general, higher abundance of striped dolphins have been observed post-Sanctuary as well as an higher presence of fin whales in the area during winter time. Changes in environmental parameters (sea surface temperature and chlorophyll) were also investigated.

X Marks the spot: Suspected broadhead arrow injuries in two bottlenose dolphins (Tursiops truncatus) along the Alabama Coast.
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The northern Gulf of Mexico is a hotspot for negative human interaction with wild bottlenose dolphins. Mortalities include fisheries interactions and intentional harm such as gunshots, arrows, boat strikes, and blunt force trauma. Since 2016, distinctive X-shaped marks of unknown origin have been documented on at least two stranded dolphins in Alabama. To determine if the origin of these X-shaped lesions were fisheries interactions or intentional harm, forensic analysis was conducted on various impression patterns of nets and weapons that could make similar markings. Clay casts and carcass reenactment was performed to test whether the lesions could be linked to a specific weapon, comparisons were made to photos of known fisheries interactions and intentional harm cases, and histopathological evaluation was performed on the lesions. While X-shaped lesions on carcasses are typically linked to net interactions or scavenging, the depth and location of lesions on the carcasses in these cases were notably different. These lesions were determined to be a pattern injury from a common source. Bruising and the presence of neutrophils at wound sites indicated these injuries were inflicted prior to death, although not the primary cause of death. The size and shape of lesions matched the structure of a 4-point broadhead arrow typically used for small game hunting or bow-fishing. This work highlights the need for detailed evaluation of atypical lesions and subtle signs of intentional harm. Results suggest that intentional harm with broadhead arrows is at least a regional concern where broadhead arrows are commonly used in small game hunting. Detailed evaluation of external lesions on cetaceans is necessary for reliable detection and diagnosis of human interactions and sharing data across stranding networks will help track local and regional trends of intentional harm to help guide management and enforcement in areas of need.

The unexpected benefits of ferries: Lessons in humility and patience from Oman and Congo.
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Tim Collins has worked on cetaceans in the Middle East and Africa for 20 years, including a focus on Endangered Arabian Sea humpback whales and the Critically Endangered Atlantic humpback dolphin. The work has required a fair mix of gumption and luck, but has also been guided by the wisdom of others. Tim works for the Wildlife Conservation Society and currently lives in Kenya.

City Slickers - seasonal occurrence and distribution of bottlenose dolphins (Tursiops truncatus) in the western New York bight.
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Bottlenose dolphins (*Tursiops truncatus*) are globally distributed in temperate and tropical climates and along most continental coastlines. Some populations or "stocks" display high site fidelity to small regions while others migrate seasonally, often composed of resident and transient animals. Their occurrence across the eastern coast of the United States extends from Florida to as north as New Jersey, yet there is limited knowledge about their inshore distribution in the New York Bight. We examined the distribution and occurrence of bottlenose dolphins in the coastal regions of the Western New York Bight. Sighting and photo-identification data were gathered opportunistically aboard a seasonal whale-watching vessel and analyzed to evaluate their distribution including group size and distance to shore. From April to December 2011–2018, there were 320 sightings of bottlenose dolphins. We detected an increase in the numbers of occurrences (87.16%) over 8 years. Large groups of 25-100

animals were regularly observed nearshore in close proximity to the shoreline (49.26%). The persistent seasonal occurrence of dolphins in the Western New York Bight represents the northern extent of their migratory range. Our findings provide important baseline data documenting the presence of this species in the New York Bight and illustrate the need for continued monitoring efforts in this area of substantial industrial development.

Estimating exposure to ship noise of the Southern Resident killer whale population in the Salish Sea, Canada

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The endangered Southern Resident Killer Whales (SRKW) of the Salish Sea, western Canada, display behavioral reactions to vessel noise, alter their vocalizations to overcome increased noise levels and are affected by masking when in proximity to vessels. As vessel traffic is expected to double by 2030, these effects could prevent the recovery of SRKW, currently down to 75 individuals. Within the scope of the Noise Exposure to the Marine Environment from Ships (NEMES) project, our study assessed noise exposure for SRKW and developed a set of geovisualization tools to support vessel noise management. We combined information on the distribution of SRKW (kernel density estimation) with the output of a cumulative noise model describing sound levels generated by commercial vessels. Cumulative distribution functions were used to evaluate SRKW's noise exposure levels and median cumulative noise values were used to identify main noise contributors within the study area. Ferries, tugboats, vehicle carriers, recreational vessels, containers, and bulkers showed high levels of exposure for SRKW. Building on these results, we developed a suite of three geovisualization tools developed as add-ons to the ArcGIS Pro platform that focused on mapping exposure hotspots, computing probabilistic levels of exposure, and identifying alternative shipping routes that would minimize exposure for cetacean species. Using the Salish Sea as a case-study, the tools were applied to test two alternative management options to reduce noise exposure for SRKW: re-routing and lateral displacement. Management actions aiming at reducing SRKW noise exposure levels during the summer should prioritize the main contributors to vessel noise in the Salish Sea and take into consideration the spatial distribution of their levels of exposure. By enabling marine managers and planners to explore and analyze acoustic and biological data, the framework and tools developed in this study facilitate the adoption and implementation of adaptive noise management strategies.

Odontoceti's humerus: A novel study on its morphometry and bone density using helical CT.

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Cetaceans are Mammals that have evolved through a series of morphophysiological adjustments of the various biological systems that allow them to live under water. One of them, the bone tissue is not fully understood and it is related both with the musculoskeletal and haematopoietic systems.

From 2016 to date, humeri of 90 specimens belonging to 11 different species were collected from stranded animals in Canary Islands (Spain). Samples were analysed by means of helical computed tomography (CT), a technique particularly effective in the study of bone tissues, allowing measurements of bone densities. These have been measured from specific cross sections of the distal epiphysis, the diaphysis and the proximal epiphysis (separating the tubercle from the head of the humerus). Bone densities of the cortical and trabecular bone have been measured separately. Collected data led to trend plots focusing on the changes of the values along bones cross sections.

Comparing these data, bone densities gradients showed a similar behaviour in individuals of the same species according to growth of each animal. Moreover it was interesting to discover that animals with similar diving habits have similar plots, thus differentiating between shallow and deep divers: deep divers have lower bone densities

in the range of 200-800 Hounsfield while shallow divers's range between 400-1600.

The objectives of this project are the anatomical description together with the morphometric and bone density studies of the Cetaceans' humerus, to obtain reference values that could help in a classification of the degree of growth of the animals, based on their skeletal development. Moreover, these data could be used to support diagnoses of pathologies related to the bone tissue.

Circum-polar analysis of Southern Ocean humpback whales

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The Southern Ocean offers some of the most remote, logistically challenging research environments on Earth, yet these waters are the feeding grounds for circum-polar populations of humpback whales (*Megaptera novaeangliae*). The more accessible Antarctic Peninsula region is the best studied habitat, but is not reflective of most of the open waters. Over the past decade, increasingly sophisticated satellite tags have been deployed on humpback whales revealing new migration paths and feeding grounds. We have compiled satellite tag data from humpback whales throughout all of the Southern Hemisphere oceans representing the different breeding grounds and/or migratory corridors. We focused on the Austral summer feeding grounds in the Southern Ocean and used state space models and environmental variables such as distance from ice edge, lagged productivity, sea surface temperature to infer behavioural states such as foraging or resting, and travelling. Humpback whales are not uniformly predictable in time or space throughout the Southern Ocean. Often considered 'ice-edge' whales, the proximity to ice-edge varied from tens to several hundreds of kilometres with lag effects of ice-concentration a strong indicator of productivity driving whale feeding areas. Near-land areas of higher productivity e.g., west Antarctic Peninsula, Balleny Islands, South Georgia and the South Sandwich Islands were important to whales, but many whales occupied discontinuous patches of open ocean waters associated with krill productivity. Our circum-polar analysis of humpback whale habitat use and movement patterns will inform the development of Important Marine Mammal Areas (IUCN). With heterogeneous changes in ice dynamics in Antarctica, this work will provide predictive habitat modelling enabling a better understanding of humpback whales' future in the Southern Ocean.

The acoustic repertoire of free-ranging bottlenose dolphins (Tursiops truncatus) in south Abaco, Bahamas.

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Quantifying and characterizing vocalizations emitted by a species is a necessary first step in understanding signal function and assessing intraspecific variability within and across geographic areas. Bottlenose dolphins (*Tursiops truncatus*) produce a wide variety of sounds used for communication among conspecifics and for interacting with their environment. In this study, recordings of a resident population of free-ranging common bottlenose dolphins made on a moored *Loggerhead* DSG-ST acoustic recording device and a 10 m hydrophone array during nearshore boat-based surveys in south Abaco,

Bahamas from 2008-2018 were analyzed. Results demonstrated that the dolphins inhabiting this region emit a variety of signal types consisting of: whistles, signature whistles, burst pulse (BP) sounds, low frequency narrow-band (LFN) sounds, and brays. Whistles had a great frequency range, between 1.31-30.38 kHz, and the mean acoustic parameters fell in range with those from other studies. In total, 11 well-defined, stereotyped signature whistle contours were identified. LFN sounds occurred infrequently and had low peak frequencies (mean = 0.52 kHz ± 0.28), short durations (mean = 0.09 s ± 0.07) and were either produced in trains or as components of bray calls. The identified BP sounds had a mean (±SD) inter-pulse interval of 2.44 ms (±1.00) with durations mostly under 0.25 s. We also report on emissions akin to moans and a potential novel signal type. This study provides baseline data for a relatively undisturbed population of bottlenose dolphins and contributes to the knowledge of the acoustic repertoire of this species.

A comparison of the external pigmentation patterns of two Cuvier's beaked whale populations as evidence towards combining photo identification data for improvements in future demographic analyses.

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Population demographics, the number of individuals within a population of know age and sex, is an important aspect of a species' biology. A model has previously been used to reliably sex Cuvier's beaked whales using external pigmentation patterns and scarring density thresholds. However, this methodology was only applied to and tested on a population from the Mediterranean Sea. To test if this methodology was robust in a different geographic population it was applied to 49 animals of known sex from the Southern California Anti-Submarine Warfare Range. A binomial GLM was fitted using the dorsal fin zone scarring density of 47 adult animals (22 females and 25 males) from the Mediterranean. A density threshold of 0.072 was calculated, with adult male classification being above this threshold. This threshold, when applied to the Californian population, correctly predicted the sex of 46 animals (94%). Furthermore, when the same model was fitted to the Californian population it correctly predicted the sex of 43 Mediterranean animals (91%). It was found that the scarring density between the between the two populations was not significantly different for males ($F(1,51)= 0.502$, $p=0.48$) or females ($F(1,51)=0.000$,$p = 0.99$). This study has shown that the modelling methods are robust across different populations. In addition, the similarity found in the external characteristics of these two populations suggests the potential for using combined photographic datasets from different populations. This would dramatically increase the amount of data available, allowing for further and more complex investigations into the demographics of this species. For instance scarring gain rate, a possible proxy for age, could be calculated from photographic identification recaptures. Currently only six adult male recaptures have been analysed from the Californian population but a scar density gain rate of 0.014 per year was found.

Feeling out your Food: A histological analysis of the vibrissal system in pinnipeds.

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The vibrissal (whisker) system is present in nearly all mammals and is especially important in deep-diving mammals. Pinnipeds have specialized whiskers that are richly endowed with mechanoreceptors and are highly innervated, indicating that they are sensitive sensory structures. Despite the biological importance of the vibrissal system, we have little comparative data across pinniped species. In pinnipeds studied thus far, each vibrissal unit consists of a follicle sinus complex characterized by a three-part blood sinus system: the upper cavernous sinus (UCS), ring sinus (RS), and lower cavernous sinus (LCS). The UCS is unique to pinnipeds and lacks innervation. Based on this lack of innervation, we hypothesize that the UCS plays a thermoregulatory role, insulating temperature-dependent mechanoreceptors. The objectives of this study are (1) to measure and compare the relative lengths of the three sinuses (UCS, RS, and LCS) across pinniped species and (2) to examine the UCS as a thermoregulatory structure. To do this, we are measuring and comparing the relative lengths of the UCS in deep-diving polar Weddell seals (Leptonychotes weddellii), deep-diving temperate northern elephant seals (Mirounga angustirostris, NES), and shallow-diving temperate harbor seals (Phoca vitulina). Skin tissue samples from the vibrissal pads were collected from Weddell seals (n=6), NES (n=4), and harbor seals (n= 2) that died

in the wild or during rehabilitation efforts. Individual vibrissal follicles were removed and histologically processed using standard methodology. We expect that the species faced with the coldest environment at depth will have the longest UCS. This represents the first study to characterize the microstructures of the vibrissal system in Weddell seals and the first study to investigate the UCS as a thermoregulatory structure. Temperature regulation of the mechanoreceptors on the vibrissae directly impacts foraging ability. Therefore, maintaining the functionality of this system under cold conditions is imperative for foraging success.

Fifteen years of data reveals insights into some of the most internationally recognised orca (Orcinus orca) in the world.

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Since 2004, we have documented the orca (*Orcinus orca*) who intentionally strand on the beaches of Punta Norte, Peninsula Valdes, Argentina. This zone (a maximum of 14 km in length), is delimited by South American sealion (*Otaria flavescens*) colony locations. Arguably, these orca are the most internationally recognised population world-wide, due to their foraging behaviour. Our database of 15 years of research illustrates that the population is extremely small (fewer than 30 individuals). There are three stable groups based on matrilineal frameworks, however there is also an element of fission-fusion structure as there are individuals who roam between the groups and others who appear for limited times within only a season or two.

Foraging, when the orca are at Punta Norte, includes pinnipeds, cetaceans and birds. When foraging is focused on sealions, we have documented up to 70 attacks in a single day (in 2018, when 15 orca were in the group). Success rates of captures (compared to attacks) during any one season, ranged from 38% to 68% and was influenced by the age classes hunting.

Although orca have been documented in all months of the year at Punta Norte, during the sealion pup hunting season (February-May), in the eight years between 2011-2018, orca were typically present on 42.5% of the days, with the longest duration between sightings being 36 days in 2018. Between 2004-2015 in any one season, this unique population of orca typically had five to seven individuals who intentionally stranded to hunt. Then, in 2016, when younger orca began hunting, the number increased to 10. As this foraging strategy is high-risk, training is a prevalent part of their behavioural repertoire, starting from a very young age. Given the small number of animals, this population is fragile and vulnerable.

A new forensic approach on cetaceans to assess drowning diagnosis and to contribute to the assessment of bycatch-linked death: The diatom test.

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By-catch is considered one of the major anthropogenic threats for cetaceans worldwide. Estimates of mortality caused by fishing activities is necessary to understand if it's a real conservation menace and if mitigation actions are required. By-catch diagnosis is currently based on gross findings, which are often non-specific and generally impaired by postmortem autolytic changes.These factors limit diagnosis to fresh or moderately decomposed stranded animals. Additional forensic approaches are needed to support by-catch diagnosis in all carcasses decomposition condition.

The research of diatoms algae used in human forensic medicine to support drowning has been investigated also in marine vertebrates: in preliminary studies, bone marrow has been considered the most suitable tissue in cetaceans due to low probability of contamination during the diatom extraction protocol. This forensic technique has been further investigated on 4 bottlenose dolphins (*Tursiups truncatus*) stranded along the north-western Adriatic sea coastline between 2017 and 2018. The decomposition code according to Geraci and Loundsboury (2005) was estimated being between 3 and 4. 2 of them were deemed to be died after interaction with fishery, according to necropsy results. The humeri were sampled for the research of diatoms in bone marrow, according to Rubini and colleagues protocol (2018).

In each animal, from 2 to 14 diatoms were found with no significative differences between the suspected by-caught ones and the others.

Despite the limited number, these results stress a relevant question related to the mechanism of death during by-catch, since it's not yet clear if cetaceans died for drowning or asphyxia, respectively allowing or not the passage of diatoms in the bloodstream. These doubts request further studies increasing the sample size, to improve this technique despite it is routinely used in forensic medicine in terrestrial mammals.

A call for more comparative studies in cetacean conservation biology.

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Some baleen whale populations have recovered remarkably well, others have not. Some odontocete populations are thriving, while others are in dire straits. Climatic and other anthropogenic variation, overlying more 'natural' stressors, in multiple comparable systems offer opportunities to make inference on processes driving resultant integrated differences. However, study sites – ocean basins for migratory whales, bays or estuaries with their individual populations of dolphins – all have their own unique features. It's unlikely that we will ever have a clean, split-plot design, from which we can make inference on processes driving cetaceans' conservation status. This does not mean that we must be condemned to inference from anecdote. To steal from Tolstoy – are all happy cetacean populations alike, and must each unhappy population be unhappy in its own way? Or are there sufficient commonalities in processes driving conservation issues that we can start to see a bigger picture? We now have cheap tools - photogrammetry; remote sample collections for physiological and microbiome assessments; health assessments – to help diagnose the causes of abundance changes. We demonstrated this recently, for some of the species on which we have been working, notably endangered North Atlantic right whales and Southern Resident killer whales. However, we can take these tools further, constructing studies that use a comparative approach using multiple populations across study sites - from ocean basins to bays - in order to strengthen our capacity to make inference on processes driving conservation status. We will demonstrate this using some of our recent work as exemplars. We need to remember that exploring new ways to make inference only becomes possible when we choose to look for these new ways. The field of nonlethal and noninvasive cetacean research is mature enough now for us to conduct these studies. Let's do so.

Co-management of marine mammals in Alaska: A case study-based review.

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Co-management of subsistence use of Alaska marine mammals is a key provision of the Marine Mammal Protection Act (MMPA). Under authority of Section 119 of the MMPA, US Fish and Wildlife Service and National Marine Fisheries Service can enter into agreements with Alaska Native organizations (ANOs) to cooperatively manage the use of marine mammals by Alaska Natives for subsistence and cultural purposes. Some of the cooperative agreements have been more effective than others, and there is general agreement that co-management partnerships can be improved. The goal of this review was to strengthen co-management relationships to improve the conservation of marine mammals in a region where they are of critical ecological, social, and economic importance. The objectives of the review were to: (1) develop a "working" definition of co-management for the purpose of the review, (2) interview co-management partners, marine mammal hunters, and resource users regarding their perspectives on co-management, and (3) develop recommendations to help increase the effectiveness of co-management relationships. With the help of a Steering Committee comprised of Alaska Natives with co-management experiences and federal resource managers, we selected three case study agreements: Aleut Marine Mammal Commission, Aleut Community of St Paul Island, and Eskimo Walrus Commission. We conducted interviews with federal agency staff and ANO members and also held focus group interviews in seven coastal communities. Findings fell into seven overarching categories: key elements of co-management; partner roles and expectations; communication; organizational structure and accountability; leadership training and transitioning; agency practices and decision-making processes; and challenges of subsistence hunting and the future of co-management. Based on our findings, we developed recommendations and suggested action items with the intent of strengthening co-management and enhancing conservation of Alaska marine mammals used for subsistence and cultural purposes.

Predicting cetacean distribution in the eastern north Atlantic (Iberian Peninsula and African coasts and Macaronesia) to support marine management

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Using six years of cetacean occurrence data collected along cargo ship routes between Iberian Peninsula and NW Africa coasts and the Macaronesian islands, we developed ecological niche models (ENMs) to predict the distribution of the eight most sighted taxa of cetaceans in the area (seven species and one genus), representative of all cetacean major groups (small delphinoids, toothed and baleen whales). Two different modelling approaches were used: presence/pseudo-absence with GAMs, including sightings collected during on effort sampling; and presence only with MAXENT, including all sightings. Variables used for model fitting included topographic (depth, slope, distance to coast, distance to seamounts), oceanographic (chlorophyll, temperature and sea level anomalies), detectability (sea-state, wind-state and visibility), geographic (latitude), and seasonal (day of the year) features.

The best model for the most frequently sighted species, *Delphinus delphis*, explained around 20% of deviance by GAM. Predictions pointed for a more northern and coastal distribution with occurrence peaks in continental (Portugal and NW Africa) and island (excluding Cape Verde) shores. MAXENT predicted distribution varied among the modelled species, illustrating narrow or broad-range (e.g., *Ziphius cavirostris* VS *Stenella frontalis*), coastal or oceanic (e.g., *Tursiops truncatus* VS *Globicephala* sp.), and northern or southern species (e.g., *Delphinus delphis* VS *Physeter macrocephalus*). Both modelling techniques were consistent and complementary, allowing an in-depth analysis on the ecological significance of each predictor and on the spatial distribution of species across the study area.

Our results are an important contribution to knowledge of cetacean distribution at basin-scale as baseline data for the European conservation agenda, especially in less-surveyed areas in open-ocean. Our models allow the definition of priority areas, monitoring plans, and conservation measures within the EEZs, which is essential to comply with the Marine Strategy Framework Directive requirements.

Exceptional survey and acoustic recording of the wild bottlenose dolphin (Tursiops Truncatus) during bycatch event in the Adriatic Sea

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Changes in marine mammal vocal structures have been investigating for decades to assess whether they correlate with stress levels or stress indicators. Because of their acoustic plasticity, the interpretation of acoustic signals of dolphins has been studied most extensively. This preliminary study describes the changes in acoustic parameters detected in whistles spectral contours in a bycatch event that involved three individuals during a midwater trawling survey using passive acoustic monitoring (PAM). The results indicate a total

number of 76 upsweep whistles, 23 during the catch event and 53 during non-catch events, that were analyzed and compared. Statistical analysis highlighted significant differences among upsweep parameters. Specifically, Dr was significantly higher ($p<0.001$) and fMax, fC, and BW were significantly lower ($p<0.001$) in the upsweeps of the catch event (Mann–Whitney U-test; $p<0.001$). Furthermore, our data show that vocal production during the catch event was characterized by a combination of two signals, an ascending whistle (upsweep) and a distinctive pulsed signal that the we denominated "low-frequency burst clouds" in the frequency band ranged from 4.5 to 7 kHz). This capture event reveals a novel aspect of T. truncatus acoustic communication, it confirms their acoustic plasticity and suggests that states of discomfort are conveyed through their language.

D-PorCCA, a new tool to study the behaviour of harbour porpoises

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The behaviour of harbour porpoises can be deduced from the variation pattern of their vocalisations. They produce only narrow-band high-frequency (NBHF) clicks, emitted in so-called click trains. Therefore, available acoustic recordings can be used to increase our understanding of their behaviour. Behavioural studies, however, are time consuming and require an accurate, automated classifier and a click train identifier. Here, we present D-PorCCA, a graphical user interface to study recordings from harbour porpoises in the wild. D-PorCCA is an independent tool developed in Matlab and includes an impulsive-sound detector and a new high-accuracy porpoise click classifier (PorCC). PorCC classifies each signal as either: noise (N), low-quality (LQ), or high-quality (HQ) porpoise click. The user can decide on the echolocation events they want to visualise, specifying the length of the click train (including both HQ and LQ clicks) and the minimum separation time between echolocation events. These events are plotted as time vs amplitude, vs inter-click interval, and vs centroid frequency (or direction of arrival, if available). Additionally, the waveform, power spectrum, and spectrogram of each click within the echolocation event is available. Click trains of interest can be easily selected by the user and extracted for further analysis. These events are then automatically cleaned of echoes and other noise sources, after which the pattern of the click train is automatically investigated to determine whether there is one or more animals vocalising simultaneously (i.e., overlapping click trains), as well as which behaviour the animal was potentially engaged in (e.g., feeding). D-PorCCA is a user-friendly tool with potential for behavioural studies of wild harbour porpoises as well as other NBHF species, as it focuses on clicks trains, and can be used to fill knowledge gaps of these elusive species. Moreover, it has potential for application in large monitoring project, such as SAMBAH.

Movement patterns, diving behavior and physiology of the leopard seal in the Antarctic peninsula.

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The Antarctic Peninsula is one of the most rapidly changing habitats in the world. To better understand the ability of the leopard seal, an apex predator in the Antarctic ecosystem, to cope with a changing environment, we examined the foraging behavior and habitat utilization of leopard seals using satellite telemetry. We deployed 12 satellite-linked tracking devices on 3 adult males, 8 adult females, and one juvenile female leopard seal on Cape Shirreff Livingston Island, Antarctica during April-May 2018. The animals ranged from 147 to 540 kg with a mean mass of 389 ± 95 kg. Three of the twelve leopard seals remained within the South Shetland Islands, while two female seals transited well to the northeast, with one stopping at South Georgia Island. On average leopard seals made short shallow dives with a mean depth of 28 ± 7 sd

meters and a duration of 3.8 ± 0.5 sd min. However, they occasionally made deep dives, with the single deepest dive being to 428 m and lasting 10.1 minutes. Their physiological parameters were consistent with a shallow aerobic diver, with a blood volume of 134 ± 5.2 sd ml/kg. Their hematocrit ranged from 44 – 56 with a mean of 51 ± 4 sd. We determined myoglobin concentrations in the locomotor muscles 6 of the animals and those ranged between 44.9 ± 1.4 se mg/gr for *Longissimus dorsi* and 32.9 ± 0.8 se for pectoralis muscle. The second season of fieldwork is underway during May 2019 and the results of these studies will be analyzed and presented. The diving and movement date are providing insight into the habitat requirements of this Antarctic top predator. Information on their habitat requirements can be used to predict how their habitat might shift as the climate changes.

Seal parapoxvirus in north American pinnipeds: A molecular and phylogenetic analysis.

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Parapoxviruses cause nodular lesions in the skin and mucosal membranes of pinnipeds and infections by these viruses have been documented in marine mammals admitted to rehabilitation facilities worldwide. Seal parapoxvirus is currently categorized as a tentative species of the *Parapoxvirus* genus.

Between 2009 and 2018, tissue samples and ocular swabs were tested from 11 pinnipeds with parapoxvirus infection with origin in rehabilitation facilities on the east and west coasts of the United States of America, representing 4 species (grey seal, harbor seal, California sea lion and northern elephant seal). Our aims were to obtain additional sequences of the parapoxviruses from the clinical samples, targeting the genes *B2L*, GM-CSF/IL-2 inhibition factor (*GIF*) and *vIL-10*, to further resolve the evolutionary relationship with other members of the genus. We also compared the sequences between different pinniped species and locations.

The sequence analysis showed that the parapoxvirus sequences from the seal samples differed significantly from parapoxviruses found in terrestrial hosts and that the pinniped parapoxviruses formed a separate cluster within the genus. Five distinct parapoxvirus variants were detected. Parapoxviruses from harbor seals from the Atlantic and Pacific coast clustered separately, indicating different virus variants in the two subspecies, likely reflecting geographical distance and co-evolution of the virus with the host. One variant of parapoxvirus was found in both a California sea lion and a northern elephant seal housed in the same facility, suggesting transmission occurred between species that belong to different families.

Results of this study support the classification of seal parapoxvirus as a separate species within the genus *Parapoxvirus* and give further insight into the phylogenetic relationships between the different circulating seal parapoxvirus strains.

The gross morphology of the internal tracheobronchial venous plexus of cetaceans

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An extensive internal tracheobronchial venous plexus (ITVP) has been described in bottlenose dolphins, striped dolphins, pygmy sperm whales, and Baird's beaked whale (Costidis & Rommel, 2012; Cozzi *et al*, 2005; Davenport *et al*, 2013; Fanning and Harrison, 1974; Ninomiya *et al*, 2005). Descriptions have mainly involved histological characterizations, so little is known about anatomical connections, extent or function(s) of the plexus. Contrast enhanced computed tomographic (CT) angiography and gross dissection were used to investigate the anatomic connections and extent of the ITVP, and to locate a main vein for targetted catheterization. The primary venous connection was found to be at the birfurcation of the right accessory bronchus. This bronchial vein connects to the intrathoracic caudal vena cava. Large numbers of the plexus veins converge in a fluvial pattern toward this bronchial veins, suggesting this vein is a major emmissary. Numerous smaller ancillary venous emissaries are present throughout the laryngeal and tracheobronchial regions and with the bronchial

vein connect the ITVP to systemic venous circulation. Connectionsto pulmonary venous circulation like those suggested by Ninomiya *et al* (2005) have not yet been found. Threshold and manual segmentation of CT data from perfused pulmonatry trees were used to calculate luminal volume occupied by the engorged ITVP. Preliminary estimates of plexus volume were 38% and 36% of luminal volume in a common bottlenose dolphin (*Tursiops truncatus*) and common dolphin (*Delphinus delphis*), respectively. Such large luminal volume occupancy could have significant effects on the physics of dive-related trachobronchial collapse, by altering the amount of dead space as well as tracheobronchial compliance. Reduced dead space will result in delayed alveolar collapse during a dive, and increased diving-related nitrogen absorption. Similarly, alterations in tracheobronchial compliance will also affect the depth of alveolar collapse. Together, these findings may provide insights for modeling pulmonary shunt and diving gas kinetics.

Aerial surveys for protected marine species around Norfolk Canyon, Virginia, USA

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As part of a larger multidisciplinary monitoring program supporting Atlantic Fleet Training and Testing (AFTT) activities, the U.S. Navy funded line-transect aerial surveys to collect baseline information on marine mammal occurrence, distribution, composition, and basic behavior within the Virginia Capes (VACAPES) range complex in the mid-Atlantic off Virginia Beach, Virginia. The primary survey area included the waters between 80 and 160 km offshore of Virginia Beach, encompassing an area of approximately 9,200 square kilometers. From April 2018 to May 2019, a total of over 13,000 kilometers of trackline was covered over 23 survey days. Sixteen cetacean species were identified, including protected species such as North Atlantic right (NARW), blue, fin, sei, and sperm whales. Also recorded were True's and Sowerby's beaked whales, which have been rarely encountered in this region previously. Other notable observations include two sightings of eight individual feeding NARW, which were in close proximity to several other foraging humpback, fin, sei, and minke whales. Additionally, a rarely encountered lone adult blue whale was seen over the continental shelf feeding amongst fin whales. In addition to cetaceans, turtles, fish, sharks, and rays were also opportunistically recorded and identified to species when possible. We have documented two species of large pelagic rays (Chilean and giant devil rays) that have likely been misidentified as a general "manta ray" during past survey efforts along the U.S. Atlantic coast. This region is a high-use area for commercial shipping and military activities, and this study is a valuable component of continued monitoring efforts to document the occurrence of protected marine species over a longer temporal span in a seasonally dynamic environment.

Offshore wind and marine mammals in the US: Integrating legal compliance and ecological needs for practicable policy development.

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Offshore wind development in the U.S. is rapidly advancing, with multiple recent lease sales on the east coast and areas under consideration on the west coast. As projects progress, agencies such as the Bureau of Ocean Energy Management and National Oceanic and Atmospheric Administration are preparing and adapting policies that may affect offshore wind projects to ensure impacts to marine mammals are within legal limitations as prescribed in the Marine Mammal Protection Act. Key challenges with policy development are related to project scaling and applied worst-case-scenarios and modeling assumptions. To adapt policies, we suggest (1) improved regulatory alignment among agencies for decision-making early in project evaluation; (2) engagement with key stakeholders such as developers and the conservation community; and (3) risk management strategies that allow more complex and realistic consideration of marine mammals' roles in ecological systems. With respect to offshore wind, we will (1) provide examples of challenges integrating marine mammal considerations under different laws and disconnections that can arise between policies and ecological goals; (2) make recommendations about application of policies to meet legal and ecological needs; and (3) differentiate between potential policies on the east and west coasts given different technologies and taxa. An example of a disconnection between policies and ecological needs is application of a larger radius to harassment for vibratory technologies because this discourages use despite reduced acute noise production.

Another example is that shutdown mitigations for geophysical surveys often are required to employ larger mitigation radii than the legal criteria would suggest are needed. Further, although laws have different purposes, we recommend early recognition among agencies of acceptable modeling approaches and coordination to ensure appropriate review and consideration of monitoring and mitigation.

Validation of dive foraging indices using archived and transmitted acceleration data: The case of the Weddell seal.

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Dive data collected from archival and satellite tags can provide valuable information on foraging activity via the characterisation of movement patterns (e.g. wiggles, hunting time). Besides, head-mounted accelerometers have proven to be effective for detecting prey catch attempt (PrCA) behaviours. However, device retrieval is typically required to access the high-resolution data they record, restricting use to animals returning to predictable locations.

In this study, we present and validate data obtained from newly developed satellite-relay data tags, capable of remotely transmitting summaries of tri-axial accelerometer measurements. We then use these summaries to assess foraging metrics generated from dive data only. Tags were deployed on four female Weddell seals in November 2014 at Dumont d'Urville, and successfully acquired data over ~two months. Retrieved archival data for one individual, and transmitted data for four individuals were used to (1) compare and validate abstracted accelerometer transmissions against outputs from established processing procedures, and (2) assess the validity of previously developed dive foraging indices, calculated solely from time-depth measurements.

We found transmitted estimates of PrCA behaviours were generally comparable to those obtained from archival processing, although a small but consistent over-estimation was noted. Following this, dive foraging segments were identified either from (1) sinuosity in the trajectories of high-resolution depth archives, or (2) vertical speeds between low resolution transmissions of key depth inflection points along a dive profile. In both cases, more than 93% of the estimated PrCA behaviours (from either abstracted transmissions or archival processing) fell into inferred dive foraging segments (*i.e.* « hunting » segments), suggesting the two methods provide a reliable indicator of foraging effort.

The validation of transmitted acceleration data and foraging indices derived from time-depth recordings offers new avenues for the study of foraging activity and dive energetics. This is especially pertinent for species from which tag retrieval is challenging.

Patterns of persistent organic pollutant concentrations in common bottlenose dolphins (Tursiops truncatus) at multiple spatial scales.

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Persistent organic pollutant (POP) concentrations increase at high trophic levels through biomagnification. Common bottlenose dolphins (*Tursiops truncatus*) are an upper trophic level species in estuarine and coastal ecosystems; thus, they accumulate high concentrations of these persistent, lipophilic contaminants. Dolphins near Brunswick, Georgia (USA) have some of the highest recorded blubber concentrations of polychlorinated biphenyls (PCB) in marine mammals studied to date. The Sapelo Island National Estuarine Research Reserve was thought to be a relatively pristine comparison site for the Brunswick study, but dolphins studied from this site also have high concentrations of POPs. Contaminant concentrations from blubber biopsies of dolphins in waterways near Savannah, Georgia (USA) were compared with other dolphins in the southeastern U.S. Male common bottlenose dolphins (n=20) were biopsied in Savannah in spring 2017; additional biopsies were collected in spring 2019 (n=51; sex to be determined). The male dolphins sampled in 2017 had significantly

lower mean concentrations of all contaminants except for dieldrin when compared to concentrations in males in the Brunswick and Sapelo locations. In addition, male dolphins in Savannah had the lowest mean concentrations of PCBs (31.1 μg/g) compared to males at 14 other locations in the southeastern U.S. These values were significantly lower than the values in animals from Brunswick and Sapelo, Georgia, indicating that Savannah could serve as a comparison site to further investigate health effects of POPs in common bottlenose dolphins from the southeastern U.S. Contaminants data were coupled with sighting histories of individuals with ≥10 sightings from 2009-2017 and mapped in ArcMap 10.4 (22.3 ± 12.1 sightings); there were no clear geographic patterns in historical sighting record versus contaminant concentrations near Savannah, Georgia. However, including additional males sampled in 2019 may indicate fine-scale spatial patterns in habitat use and contaminant levels similar to the broad-scale spatial patterns found between field sites.

A different kind of wax museum: Forecasting population trajectories of baleen whales using reproductive parameters from earplugs.

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It is logistically difficult to obtain reliable estimates of baleen whale growth rates when sampling populations of low densities and/or in complex habitats. Here we evaluate baleen whale population dynamics by analyzing progesterone, the pregnancy hormone, in baleen whale waxy earplugs (N = 11, total lamina = 835, age range = 13 – 63 years). To identify pregnancies, we calculated percent change in progesterone from the previous lamina, ranked these points, conducted a sensitivity analysis, then assigned the top 30% of points as pregnancies. From these pregnancies, we estimated age at first pregnancy, pregnancy intervals, and pregnancy rate. Our results matched well with published calving intervals, age at first birth, and birth rate. Alternatively, if we inferred pregnancy using 40-50% progesterone percent change cutoffs we estimated higher pregnancy rates, which suggests some conceptions do not necessarily result in birth or the calf does not survive long afterward. Next, we compared multiple individuals for age-specific fecundity (aligned by age). Our results demonstrated, for the first time, age-specific fecundity in fin whales (n = 3, total lamina = 117), as well as reproductive senescence beginning at 25 years and theoretically reaching zero fecundity at 75 years. Finally, we modelled the maximum rate of increase (ROI) of a population of fin whales using a ROI model which includes age-specific fecundity and reproductive senescence. Compared to the standard ROI model, our results suggest a 22.8% reduction in future population size when projecting the ROI from each model forward to the year 2050. Using a model that incorporates age-specific fecundity and reproductive senescence is vital to effective management and can be used to assess how exposures to stressors can impact vital rates of baleen whale populations over the long-term. These results represent significant departures in population trends for these long-lived and vulnerable species.

Song production by the eastern North Pacific right whale, Eubalaena japonica.

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Song has not been documented in any right whale species. Here, we present evidence of song production by the eastern North Pacific right whale (NPRW, *Eubalaena japonica*), in the southeastern Bering Sea. Songs were localized to calling NPRW in real-time using directional sonobuoys; singers whose sex could be determined were all males. These sonobuoy data and autonomous recorder data from 17 year-long deployments were analyzed to document and characterize song types. Four unique song types were documented over eight years (2009-2017) at five distinct locations. Each song type consists of a hierarchical structure of 1-3 different repeating phrases comprised predominantly of gunshot calls; three of the four song types contained additional sound types (downsweep, moan, low-frequency pulsive call).

Songs were detected every year from July through early January; all four song types remained consistent over eight years. Two different songs often occurred simultaneously, produced by different animals; the same song was never detected simultaneously at the same location. However, the detection of the same song on the same day and time at two locations 310 km apart indicates multiple animals can produce the same song. These findings provide support that male NPRW produce song; it remains unknown if females also sing. We hypothesize that these patterns may be a reproductive display similar to song in other mysticetes. Although song has not been documented in congeneric right whale species, songs presented here fit the classification of song attributed to other cetacean species. Possible functions of these songs and their management implications will be discussed.

Oceanographic characteristics associated with movements and high-use areas of spotted seals (Phoca largha) in the Chukchi and Bering seas.

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Spotted seals (*Phoca largha*) are pelagic foragers that use seasonal pack ice for pupping, nursing, and resting when ice is present (December–June) and coastal haulout sites for resting during the open-water season (July–November). Decreases in the extent and duration of ice cover associated with climate change have eased access to the Arctic for development and shipping, prioritizing the identification of areas important to seals. We worked with Alaska Native hunters to deploy satellite-linked tags on 24 spotted seals (including 20 CTD tags) in nearshore areas of the Beaufort and Bering seas during 2016–2018 to study movements and identify high-use areas. Individual seals were tracked for 137–638 days. Seals tagged in the Beaufort Sea moved into the Chukchi Sea and made recurrent east-west movements, spending 1–27 days foraging near Herald Shoal, primarily in warm Alaskan Coastal Water, and 0.1–5.7 days resting on coastal islands. Seals tagged in the Bering Sea also made recurrent east-west movements, spending 1–25 days foraging in the central Bering Sea, primarily between St. Lawrence Island and St. Matthew Island in Alaskan Coastal Water and Bering Shelf Water, and 0.03–6.2 days resting on coastal islands. In December, seals in the Chukchi Sea moved south, ahead of the advancing pack ice, into the Bering Sea. By mid-January, all seals regardless of their tagging location foraged along the pack ice edge in the central Bering Sea. CTD data will be used to identify oceanographic characteristics of the high-use foraging areas. Tagging seals in both the Beaufort and Bering seas allowed us to identify spotted seal movements and high-use areas throughout the continental shelf. Further studies that include additional tagging locations will likely identify other important foraging and resting areas.

Lessons learned from decades of swimming with dolphins: A New Zealand case study.

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Over recent years, cetacean watching has experienced extensive global growth in size and scope. Patron interest in close interactions has prompted industry expansion to include cetacean swimming. This activity persists, despite numerous studies detecting alterations (*i.e.,* avoidance, increased activity, behavioural budget) with potential cumulative effects identified. New Zealand is a global leader in industry development, specifically amongst swim-with-dolphin operations. As such, this case study was designed to investigate swim-with-dolphin tourism management by examining 1) long-term swim-with-dolphin trends and 2) the engagement of *Nationally Endangered* bottlenose dolphins in swim-with-dolphin encounters, modelled via several proxies. Two datasets, spanning nearly two decades, from Queen Charlotte Sound, New Zealand (QCS), were analysed. A total of 5,295 tourism logbook records from January 1995–November 2011 were collated and 145 bottlenose dolphin swim encounters were assessed aboard a tour vessel from November 2011–April 2014. Logbook records indicated regional expansion of swim-with-dolphin tourism, consistent with global trends. Observed swim encounters included up to five attempts (duration mean=4.2 min, SE=0.15, n=493), primarily when dolphins were travelling (43.2%, n= 60). Most vessel approaches were invasive (*i.e.,* "J" or in-path; 74.5%, n=347), with calves/neonates present during 77.9% (n=113) of swim encounters. Proxies for dolphin engagement

were analysed via linear or generalized linear models. Proxies included 1) dolphin reactions (primarily neutral; 82.9%, n=387); influenced by swimmer orientation, initial dolphin behaviour and dolphin group size and 2) distance operators travelled to track dolphins during swim encounters (mean=11.7 km, SE=0.46, n=140); influenced by location in QCS, initial dolphin behaviour and dolphin group size. Findings suggest animal habituation, operator pursuit of interaction and ultimately, lack of dolphin engagement; outcomes that may equate to negative consequences for this population. Moreover, this research highlights inconsistencies within NZ Marine Mammals Protection Regulations (1992) that require attention. The study concludes with valuable recommendations for tourism management.

Investigating epigenetic manifestations of stress in southern resident killer whales

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Most studies testing for genetic impacts on individual fitness and population viability are based on patterns of DNA sequence variation, such as homozygosity and/or the presence of specific alleles. However, theory and research show that the largest impacts are likely due to changes in gene expression, rather than sequence variation itself. In the Northeast Pacific Ocean, Southern Resident killer whales are critically endangered and only 75 individuals remain. Despite conservation efforts, they face continued anthropogenic stressors such as noise/disturbance from vessels and nutritional limitations. Increased stress can lead to a number of negative fitness consequences, such as higher rates of disease and increased signs of ageing. These long-lasting effects are largely due to epigenetic changes in DNA methylation patterns. We investigated epigenetic manifestations of stress in Southern Resident killer whales compared to the closely related, less disturbed and more robust population of Northern Residents. We used bisulfite amplicon sequencing to compare patterns of DNA methylation in three genes involved in stress response (BDNF, CRH and NR3C1) and two control genes (GAPDH and ACTB) between these two populations. Comparison of methylation patterns between these populations in stress response genes, relative to the control genes, identify the degree to which anthropogenic stressors are manifesting themselves genetically in the Southern Resident killer whales. With these data we have also estimated the effect of these epigenetic changes at a population level, and thus provide a direct mechanistic link between anthropogenic stress and fitness outcomes via the key intermediate link of epigenetic changes.

In plane sight: A capture-recapture study of North Atlantic right whales in the southern Gulf of St. Lawrence from an aerial platform.

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The decline and observed occupancy shifts of the North Atlantic right whale (*Eubalaena glacialis*) beginning in 2010 have prompted dedicated survey effort in new areas. Historically, right whales have been sighted in the southern Gulf of St. Lawrence (Gulf) and this area has been hypothesized as suitable habitat, but one previously lacking substantial survey effort. Capture-recapture aerial surveys were focused around the Orpheline Trough and Shediac Valley regions in the southern Gulf between June and August. A total of 153 unique individuals were identified (2015: $n = 35$; 2017: $n = 105$; 2018: $n = 131$) over 45 survey days (2015: $n = 4$; 2017: $n = 15$; 2018: $n = 26$), and the demographic breakdown of these individuals was similar to that of the entire population. Of the individuals identified, 87% were captured on more than one survey day, and 73% of the animals captured in 2018 had been captured in previous seasons. Best fit Jolly-Seber models were used to estimate abundance within 2017 and 2018 resulting in approximately 6 (SE 5) and 1 (SE 1) whale(s) going undetected, respectively. These results suggest almost all animals present were captured using this survey methodology, and there is a high rate of inter-annual return within these individuals. After an unprecedented 12 right whale mortalities

were documented in the Gulf in 2017, zero calves were observed in the following calving season, and of the seven females that calved in the 2018/2019 calving season, four had been sighted in the Gulf in the preceding summers. The recovery of this endangered species relies on the ability of adult females to thrive and reproduce, and with approximately one third of the population observed in the southern Gulf, these analyses demonstrate the importance of this feeding area for right whales.

What do whales look like from space?

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Satellites orbiting 600km away from Earth could potentially provide new and invaluable information for whale conservation. They can access places, rarely surveyed by boats or planes, due to the inaccessibility of such areas. Some satellites can now provide images with a very high resolution (under 50cm), allowing for the detection of large-sized whales. We have been testing the feasibility of using satellite imagery as a reliable method to study whales. We used the WorldView-3 satellite, which offers the highest commercially available spatial resolution of 31cm. We showed that four whale species could be detected, including fin whales (*Balaenoptera physalus*), southern right whales (*Eubalaena glacialis*), grey whales (*Eschrichtius robustus*), and humpback whales (*Megaptera novaeangliae*). The 31cm resolution allowed us to detect whale-defining features, such as flippers and flukes. Using these results, we are now focusing on automating the detection of fin whales in the Ligurian Sea and understanding how deep below the sea surface we can detect whales.

Is relocation of cetaceans from certified zoos and aquaria to marine sanctuaries an option?

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Animal rights organisations demand relocation of marine mammals from certified parks to sea-side enclosures. Is that advisable? By comparison to their natural habitat, aquaria are small and shallow, but the same is true for any type of sea-side sanctuary. What issues are at stake?

To ensure optimal care, veterinarians, trainers and technical personnel control a variety of indispensable activity, health, water and food parameters. Under optimal conditions, marine mammals form tight bonds and interact with their trainers and are frequently rewarded. Similar high levels of professional care and interaction would be indispensable in any facility.

Many existing collections are captive-bred hybrids. They do not match genetic, social, acoustic or behavioural characteristics or bacterial fingerprint of wild populations. Unplanned release from enclosures, by Illegal activities, natural disasters or mechanical failures cannot be ruled out. However, their introduction into the wild would put these animals as well as local environments and populations at risk and is prohibited by international legislation.

Dolphinids reach old ages, orcas living longer than 50 years and caring for them constitutes a long lasting financial and ethical commitment. Several governments and institutions have decided to end captive breeding and fade out collections. However, a loss of facilities and expertise will affect the possibilities to save critically endangered species.

Sanctuary projects seem to struggle with legal, professional, and economic aspects and the duration of the commitment they can guarantee. I propose to turn the focus of the debate on commercial capture operations, the welfare of cetaceans in sub-optimal facilities including sea pens and to cooperate with certified aquaria in enforcing best practice and the rescue of endangered species.

Broad-scale acoustic monitoring for cetaceans and underwater noise in relation to offshore wind farm construction in Scotland.

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Marine construction projects, such as offshore wind farms and port developments often use techniques that produce significant levels of noise underwater, which could have effects on marine wildlife. Marine Scotland is the government body responsible for regulating these activities in

Scottish waters and for ensuring that wildlife populations are protected in line with legislation.

Large scale offshore wind farm construction started off the Scottish east coast in 2017, using piled foundations. To monitor for potential broad-scale changes in the distribution of protected cetacean species during construction activities, Marine Scotland deployed an array of 30 click detectors and 10 broadband acoustic recorders across the Scottish east coast each summer since 2013. Here we present baseline distributions for dolphins and harbour porpoises, along with ambient noise levels recorded concurrently.

Dolphin detections across the monitored area are highly variable, with some locations that are clearly favoured. Harbour porpoise are ubiquitous and in more than 60% of locations are detected on 100% of monitored days. This is likely to mean that there is more power to detect changes in porpoise distribution in relation to offshore wind farm pile driving than for dolphins.

U.S. import rule on bycatch: An NGO perspective.

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The United States – the world's largest importer of seafood – issued a new regulation that will ban seafood imports from nations whose fisheries kill marine mammals in excess of the United States' own strong bycatch standards. The U.S. has already begun implementing the rule, which will be fully effective in 2022 and may affect over 120 nations around the world. Exporting nations have already begun tracking, assessing, and limiting their bycatch in response to the rule, in order to maintain access to the lucrative U.S. market.

The presentation will provide an NGO perspective on the U.S. imports rule, including its standards and implementation, and discuss where the rule may be most effective and its potential limitations. We will provide case studies evaluating the rule's impact thus far, including the U.S. decision to ban certain Mexican imports due to bycatch of critically endangered vaquita. We will conclude by identifying how researchers, conservationists, and NGOs around the world can contribute to the process by providing critical data and information.

The impact of dredging activity on harbour porpoise, Phocoena phocoena, behaviour in Dublin Bay.

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As part of Dublin Ports 6-year Alexandra Basin Redevelopment Project parts of Dublin Port and it's navigational channel are being deepened to -10m Chart Datum to accomodate larger cargo ships and cruise liners. This dredged material is dumped within a designated spoil zone approximately 15km from Dublin Port and which is located within a Special Area of Conservation (SAC) for harbour porpoises (*Phocoena phocoena*). Specialist underwater acoustic data collection equipment called C-PODs have been deployed in this spoil zone from December 2016 until present. This equipment collects digital information on detected cetacean click trains. The objectives of this study are to use this data to determine the level of foraging activity within this dump zone using a click train parameter called inter-click interval, and to compare foraging activity from before, during and after dredging activity has occurred. This will allow the aim of the research to be addressed: whether dumping activty from dredging work impacts harbour porpoise behaviour, specifically foraging behaviour.

Scoring of the severity of sperm whale behavioral responses to pulsed and continuous active sonar signals

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This study investigates how naval sonar affects sperm whales' behavior. In previous work, we showed that controlled exposure experiments (CEEs) of 1-2 kHz pulsed active sonar (PAS) induced costly behavioral responses in whales (e.g. cessation of feeding), similar to anti-predator responses. Since then, new continuous active sonar (CAS) systems are being developed to improve target detection. This raises new concerns about how CAS might affect whales' behavior. To address this question, we conducted CEEs of 1-2 kHz CAS and PAS on sperm whales in Northern Norway, and compared behavioral changes displayed during both sonar types and a no-sonar control. We inspected the behavioral data recorded by acoustic and movement recording tags (Dtag) and visual observations of the tagged whales, and we used a severity scale, revised from Southall et al. (2007) ranging from 0 to 9, to assign severity scores to behavioral changes during exposure sessions. A blind procedure was applied to ensure that any unconscious biases of the scoring panels did not result in differences between exposure types. The results show that sperm whales hardly responded to the no-sonar control. Most severe responses (severity≥4, with potential to impact vital rates) were scored during both PAS and CAS exposures and included cessation of feeding, horizontal avoidance responses and changes in social sound production and dive behaviors. They started at received SPLs (sound pressure levels) and SELs (sounds exposure levels) of respectively 119-160 dB re 1 µPa and 137-177 dB re 1 μPa^2s during CAS, and 138-175 dB re 1 µPa and 143-181 152 dB re 1 μPa^2s during PAS. Highest scores (severity=6) were associated to cessation of feeding or avoidance responses scored during PAS exposures. Less severe responses (severity<4) concerned mostly changes in vocal and dive behaviors during CAS, whereas during PAS they could also involve changes in group distribution.

A comparison of three analytical techniques for population monitoring of coastal odontocetes.
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Determining the appropriate method of population monitoring to inform conservation measures depends upon management objectives, species ecology, available resources, and geographic location. Here, we evaluate the relative effectiveness of three abundance estimation techniques: mark-recapture, line-transect distance sampling, and density surface modeling using data collected on odontocetes in Maui Nui, Hawaii. From 2013-2018, 317 systematic boat-based surveys were conducted to estimate the abundance and distribution of island-associated stocks of bottlenose dolphins (*Tursiops truncatus)*, spinner dolphins (*Stenella longirostris longirostris)*, pantropical spotted dolphins (*Stenella attenuate)*, and false killer whales (*Pseudorca crassidens)*. Standard photo-identification and distance sampling techniques were used and resulted in 247 encounters and 569 marked individuals. Abundance estimates were calculated using open populations models (mark-recapture), a Horvitz-Thompson estimator (distance sampling), and Generalized Additive Models (density surface models). The efficacy of each technique was evaluated using power analysis to determine the probability of detecting a decline of 50% over a 15-year period, at which point a stock could be classified as "depleted". Estimates for each species varied but were most consistent across techniques for bottlenose dolphins ($Abundance_{SD}$ = 17.24). Best models, based on published abundance estimates and model fit, produced estimates of 90 bottlenose dolphins (95% CI = 47-133, distance sampling), 406 spinner dolphins (95% CI = 266-547, mark-recapture), 336 spotted dolphins (95% CI = 246-427, mark-recapture), and 53 false killer whales (95% CI = 17-88, mark-recapture). Mark-recapture estimates were consistently more effective across all species with an average probability of 96.5% in detecting a decline of 50% over a 15-year period. This study highlights the importance of establishing population monitoring goals to guide data collection and analysis and presents a framework for future monitoring of small stocks of odontocetes, such as those resident to the Hawaiian Islands.

MiCO: An online system to explore important use areas and migratory connectivity for marine species.
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Areas of the ocean used by highly migratory marine species for life-cycle activities and the connectivity among these important areas have been described within hundreds of peer-reviewed publications. Currently, no centralized system exists to access actionable knowledge about global migratory connectivity across marine mammals, seabirds, sea turtles, and fish, hindering the ability of decision making policy fora to quickly leverage this information. MiCO (Migratory Connectivity in the Ocean) is a publicly accessible system for policy makers, managers, researchers, and conservation groups to explore important areas of use (nodes) and the corridors connecting them. Various system entry points allow users to explore by species, country, or data contributor; filter results by attributes or regions of interest; intersect areas with management boundaries; view an interactive abstract network diagram; and download summary reports or ESRI shapefiles. Georeferenced nodes and corridors are generated from contributed telemetry data. A state-space model is fit to estimate true locations and temporally normalize the data, then each track is segmented into migrating and non-migrating portions. Kernel density estimates are derived for each segment, and the 90% UD polygon is used to represent the node or corridor. Initial results from 47 humpback whales tagged in the Antarctic Peninsula reveal a migratory corridor connecting a foraging node in Antarctic waters with a breeding node in Colombian and Ecuadorian waters, with whales passing through national waters of Argentina, Peru, Chile and areas beyond national jurisdiction. MiCO is a developing prototype that will eventually house multiple data types demonstrating connectivity, including telemetry, genetic, mark and recapture, passive acoustic and stable isotope data. Understanding the spatio-temporal and abstracted movements of highly migratory species is vital to the ongoing efforts to conserve species, manage human activities, and to inform future research efforts both within exclusive economic zones and in areas beyond national jurisdictions.

Bayesian mark-recapture assessment of Cuvier's beaked whales on a navy sonar range

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Beaked whales are sensitive to mid-frequency active sonar (MFAS), with responses to exposure ranging from behavioral and likely physiological changes to mass stranding events. Assessment of population-level impacts of MFAS on beaked whales is challenging due to the elusive nature of these prodigious divers. An eleven-year photo-identification study of Cuvier's beaked whales (*Ziphius cavirostris*) in the San Nicolas Basin west of San Clemente Island, California revealed widespread, high interannual site fidelity, despite frequent sonar use on a coincident Navy training range. Sighting probability for *Z. cavirostris* was enhanced by leveraging automated acoustic detections from the Navy's acoustic array, which monitored the basin synoptically for beaked whales. We used Bayesian mark-recapture models to assess the annual apparent survival, abundance, and annual rate of change in abundance of *Z. cavirostris* using the San Nicolas Basin. We used simulation to assess our power to detect a change in abundance over the current time series and under several scenarios of increased sample size. We found high apparent annual survival and no evidence of a declining trend in the small local population of *Z. cavirostris*, but the uncertainty of our estimates and the results of our design analysis underscored the need to continue monitoring and to gather complementary information on the movement ecology and reproductive rates of *Z. cavirostris* in the San Nicolas Basin to better assess their status and trajectory.

Gulf of Mexico Dolphin Identification System (GoMDIS) – A collaborative program to better define bottlenose dolphin (Tursiops truncatus) movements.

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The 2010 *Deepwater Horizon* oil spill and Unusual Mortality Events in the northern Gulf of Mexico demonstrated the need for an improved understanding of bottlenose dolphin (*Tursiops truncatus*) movement and ranging patterns in this area. No mechanism existed for detecting and monitoring changes in distribution in response to these events, or for readily identifying the origins of stranded dolphins. To address these issues, a collaboration was formed in 2012 involving federal and state agencies, non-profits, and academia working on photo-identification projects, as well as stranding programs and international partners. The Gulf of Mexico Dolphin Identification System (GoMDIS) provides a venue to archive dolphin identification data from collaborating research groups Gulf-wide, including Cuba and Mexico. The objectives are: 1) maintain a collaborative compilation of dolphin identification data, 2) build and maintain a repository for identification images and 3) facilitate data sharing among colleagues to examine dolphin movements throughout the Gulf. The Chicago Zoological Society's Sarasota Dolphin Research Program (SDRP) curates GoMDIS. Data are provided by our contributors and stored both offline on our secure server at SDRP, and on Duke University's OBIS-SEAMAP that provides an online workspace for collaborators to go through animal matching workflow. GoMDIS is constantly updating, currently including 32 catalogs, 19,456 animals and 33,621 images, yielding 1,248 matches between projects (current and archived) to date. We expect GoMDIS to grow and evolve as a long-term conservation tool and resource for management. We also envision extending our study region to the wider Caribbean for better understanding of ranging patterns and shifts. To ensure continuing success, it will be necessary to 1) find funding for operations, 2) incorporate new research and stranding programs, 3) receive and process catalogs with an improved data processing framework, and 4) maintain communication between the curator and collaborators.

High genetic diversity of Southwestern Atlantic sei whales (Balaenoptera borealis) and evidence of strong genetic differentiation with North Atlantic Ocean

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Like other rorqual whales, sei whales (*Balaenoptera borealis*) were commercially hunted almost to depletion in the 20th century. The species is one of the least studied whales, and the impacts of whaling on genetic diversity and population structure for sei whales from Southwestern Atlantic Ocean (SWA) are still unknown. We present the first analysis of genetic diversity, based on mtDNA control region sequences and microsatellite genotypes, for SWA sei whales and evaluate the consequences of commercial whaling on the genetic variability of this population. Also, to investigate the phylogenetic relationship between these whales and North Atlantic (NA) sei whales, we compared our mtDNA haplotypes to sequences previously reported (7 haplotypes representing 84 individuals) on GenBank. Biopsy samples (n=20) were collected in the South and Southeast regions of Brazil between 2016 and 2018, during the Cetacean Monitoring Project in Santos Basin (PMC-BS/PETROBRAS). The SWA population showed a high genetic diversity for both mtDNA ($h=0.953$, $\pi=0.8\%$) and microsatellite ($A=10.33$, $H_O=0.760$) markers, which are much higher than that of NA sei whales ($h=0.520$, $\pi=0.2\%$; $A=6.18$, $H_O=0.650$). Additionally, no genetic bottleneck was detected. We found strong and significant mtDNA genetic differentiation ($FST=0.816$, $p=0.000$) between SWA and NA sei whales. However, although the genealogy estimated from the mtDNA sequences showed a clear division of the haplotypes into a SWA and a NA clade, one haplotype (Hap_6) detected in a single sample from the Azores was included in the SWA clade. Our results show that SWA sei whales have retained high levels of genetic diversity after whaling. Preliminary results also indicate differentiation between SWA and NA populations, but the position of one NA haplotype in the SWA clade suggests a recent migration of the maternal lineage. These findings are important for understanding the population structure, migratory connections and isolation of sei whales in the Atlantic Ocean.

Humans and whales under the weather: Using generalized additive models to predict visitors of the largest marine and whale museum of Germany.

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Public outreach is one of the most important components of conservation science. Often social media campaigns are believed to be successful, museums are believed to be places that cannot achieve these large audiences. The German Oceanographic Museum is the most visited natural history museum of Germany. Since the opening of the Ozeaneum in 2008 over 10 Mio people have visited our exhibitions. We work along the principle "Sensitize– make problems visible - show solutions. With annual campaigns we are calling for "No Plastic Ocean" and "No Noisy Seas". With these campaigns we are raising awareness. While it is clear that those campaigns reach the interested public, they are targeting a much broader audience than social media campaigns. We achieve awareness in newspapers, magazines, radio and television and implement the topics into our advertising. After being honored as "European Museum of the Year 2010" and reaching more than 1 Mio visitors per year, especially the Ozeaneum, no longer "new", was losing visitors. In 2013 strict restrictions of the funding bodies even called for a "resurgence plan". 2013 was however also a perfect weather year, when visitors did not want to leave the cozy beaches of Mecklenburg-Vorpommern. We therefore used generalized additive models of our visitors to detect the causes of decline and also see whether a future drop in attendance rates is probable. The analysis showed, that 2013 was not the worst year since the opening of the Ozeaneum and that other effects like public holidays with high temperatures, cloud-cover, rain and snow are having a huge effect on the attendance rates. The models constructed are highly reliable (R^2-adj of 52 %) and provide a basis for ongoing discussions about the future of natural history museums under the weather.

Persistent organic pollutants in blubber of Sei whales (Balaenoptera borealis) from South Atlantic.

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Persistent organic pollutants (POP) such as polychlorinated biphenyls (PCB), polybrominated diphenyl ethers (PBDE), and chlorinated pesticides are highly lipophilic compounds that can be found in several organisms, such as the marine mammals as Sei whales (*Balaenoptera borealis*) that are largely open ocean whales. Sei whale is found in all oceans, but usually live in temperate waters. It is believed that this species migrate considerable distances between higher latitude in summer to lower latitude in winter. In the southern hemisphere, the occurrence of this species was recorded in waters off Brazil, Chile, Peru, South Africa and South Georgia. A total of seven samples were obtained from unrestrained living Sei whales using biopsy darts in Santos Basin, Brazil, for analysis of POP. The concentration of POP in the blubber samples were relatively low and presented, in ng g^{-1} wet weight (ww), maximum concentration of 32.0 for PCB, 3.77 for hexachlorobenzene, 1.35 for p,p'-DDE, 1.14 for Dieldrin and 0.26 for PBDE. The present study showed lower levels of POP in Sei whales found in South Atlantic compared to those reported in the Northern Hemisphere. It may be related to their low level in the trophic web and can also be associated to a lower degree of POP contamination in that area. This study has contributed to mitigate the lack of scientific data about POP contamination in this species not only in South Atlantic but also in Southern Hemisphere.

Aggression towards neonates and possible infanticide in the Boto, or Amazon river dolphin (Inia geoffrensis).

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Observations of attacks by adult male Amazon river dolphins, or botos (*Inia geoffrensis*), together with post-mortem examinations of carcasses from within and near the Mamirauá Reserve, Brazil, suggest that some proportion of calves suffer direct aggression from adult males, with some perhaps dying as a result. No cases of female attacks on calves and infanticide have been witnessed. The benefits to males of attacking and killing calves are currently unknown for botos. As some attacks do not result in the death of the calf, mortality, if it occurs, may be an inadvertent consequence of the behavior rather than the motive for it. Our observations suggest that males who commit infanticide are unlikely to gain direct fitness benefits in terms of accelerated return of females to reproductive condition. By contrast, our observations suggest that male aggression against calves may represent a form of socio-sexual or group display. Strikingly, and unlike most documented examples in other species, infanticide-like behavior in botos is most of the time seen to be a group phenomenon. Even if unintended, the death

of calves from male aggression may have significant negative population-level impacts, given how in this species females produce only single calves at intervals of several years.

Analysis of manatee ear bone chemistry as a tool to track West Indian manatee migrations in the northcentral Gulf of Mexico.

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Migration, habitat use, and diet of West Indian manatees in the northcentral Gulf of Mexico (nGOM) are minimally studied and critical for determining population connectivity and conservation needs. Chemical analysis of inert tissues with annual growth (i.e. ear bones, otoliths, baleen, hair) provide information about migration pathways, habitat use, and diet during an individual's lifetime. These analyses can build on other studies (e.g.; satellite/GPS tags, photo identification, opportunistic sighting) without requiring capture or sighting. We examined variations in trace element ratios (e.g. Sr:Ca, Ba:Ca, Zn:Ca) and stable isotope signatures ($d^{13}C$ & $d^{15}N$) among growth layers within and among individuals to better understand variations that may correspond with seasonal migrations or ontogenetic changes in habitat and/or diet. Manatee ear bones were collected from necropsied animals along the nGOM coast from Mississippi to the western Florida panhandle and the western Florida peninsula to evaluate regional differences between these groups. Preliminary results indicate that Zn:Ca ratios increased within individuals through time, while some individuals had Sr:Ca and Ba:Ca ratios that followed annual patterns in variation of saltwater versus freshwater influence through time. Changes in Sr:Ca ratios and isotope signatures occur around 1-2 years, indicating a potential diet shift as individuals transition from a milk- to forage-based diet. Regional differences exist in some elements (Sr:Ca, Mg:Ca, $d^{13}C$), with trace element ratios higher and $d^{13}C$ values lower in animals in the nGOM than peninsular Florida. Use of these techniques will provide a novel method for reconstructing past migration, habitat use, and diet which will aid in understanding current and historical habitat use by West Indian manatees in the nGOM.

Influence of human population size, proximity and development on the presence of antimicrobial resistance genes within the intestines of pinnipeds

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Microbial marine pollution has been proven by the presence of bacterial pathogens of human and cattle origin within the intestines of pre-weaned grey seal pups born on the Isle of May (IoM), Scotland, UK suggesting significant land-sea-land transfer. The proximity to large human and cattle populations, even in highly developed countries with modern sewage treatment facilities, was considered to be the main risk factor. Antimicrobial resistance (AMR) is of critical concern and considered to be driven by over/inappropriate use of antimicrobial therapy against human and veterinary bacterial pathogens. We investigated the resistome, the presence of antibiotic resistance genes in both pathogenic and non-pathogenic bacteria, by rectal swabbing various species of pinnipeds in; 1) close proximity to (IoM) and 2) distant from (Monach Isles, Scotland) a large human population in a highly developed country, 3) close proximity to a limited but increasing human population (Caamaño Island, Galápagos, Ecuador) and 4) an oceanic island remote from human habitation (Gough Island, Tristan de Cunha, UK). DNA was extracted from rectal swabs and the resistome, including respective relative abundance, was analysed using high throughput WaferGen SmartChip qPCR technology. A total of 40 AMR genes (AMG) were detected that encoded resistance to several antibiotics including sulphonamide, tetracycline, β-lactam, amphenicol and efflux-pumps. Samples from the IoM, Galapagos, Gough and Monach islands had 21, 37, 4 and 1 AMG, respectively, but the greatest relative abundance, ≥10 fold, was on the IoM.

To our knowledge, this is the first study reporting the resistome in pinnipeds in areas of contrasting human populations using a culture-independent method. Understanding the possible source of ARG will allow us to evaluate their occurrence and spread within coastal and global ecosystems.

This is not the drone you are looking for…. The challenges of adopting new UAS technologies in marine science.

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Rapid growth in affordable unoccupied aircraft systems (UAS) has resulted in widespread uptake of these high-resolution data samplers by the marine science and conservation community. UAS provide alternative approaches for marine mammal data collection, but present challenges in terms of safe operation and baseline limitations of data quality. Here we address two specific challenges faced by new UAS operators: 1) expectations of data quality dictated by platform and sensor choice and, 2) the logistics of sustained safe operations. Understanding data errors and accuracy of UAS photogrammetric measurements is critical. In terms of data quality, we compare photogrammetric accuracy across 6 UAS aircraft by taking 10 images at 10m increments from 20m to 120m altitude using a floating scale bar for calibration. We conducted this procedure for ten combinations of aircraft, camera, and altimeters. All data were analysed by two independent observers and comparisons reveal that consumer off-the-shelf (COTS) UAS returned up to 12% error (+/- 3.07) in photogrammetric measurements compared to 0.5% (+/- 0.30) error for custom sensor packages. Unlike occupied aviation, UAS has limited data available for users regarding points of failures and life expectancy. This reduces capacity for planning, maintenance, and budgeting for the safe and useful life of these systems, which in turn increases risk of aircraft failure, decreases pilot and animal safety, and hampers successful data collection. We detail enterprise-scale maintenance and monitoring workflows for UAS, providing evidence of failures experienced for both custom and COTS platforms. These workflows clearly indicate how consistent collection and assessment of technical flight data can guide operators towards best practices and to help them understand the boundaries of this technology as they are explored.

Porpoise Listening Station – Long-term monitoring of harbour porpoise in relation to noise and artificial reef structure.

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Loud vessel noise been found to affect foraging of tagged harbor porpoises but little is known about effects of vessel traffic on their long-term behavior. In spring 2017, a live research and public outreach porpoise monitoring system was deployed at 10 meters depth on the seabed next to an artificial reef in a high porpoise density area in Little Belt, Denmark. The study area lies between two bridges and frequently used by recreational vessels and commercial shipping. The high porpoise density and the complex mixture of anthropogenic underwater noise makes the area ideal for investigating whether porpoise presence is affected by vessel traffic as measured by echo sounders throughout the year. The permanent live hydrophone system includes two underwater cameras, one above water and an AIS logger, and has collected data since March 2017 using Pamguard. The results demonstrate that porpoises are present in the area year-round and displays a strong diel trend with almost four times more echolocation activity during night (78% of all positive porpoise minutes across years). There is a seasonal variation in porpoise detections with higher activity in April-May and November-December. Background noise levels increase during the day, with 91% of the total echo sounder detections occurring in daylight hours. The observed behavioral pattern could be due to the elevated vessel noise at day and/or prey availability during night. However, in June-August there are more daylight porpoise detections and peak of echo sounder detections from vessels, indicating that porpoises do not necessarily avoid the area during elevated vessel activity. Studies on artificial reefs have shown strong attractions to higher food availability during dark hours. We therefore hypothesize that a strong motivation to feed on the reef predominantly during night is due to prey

availability more than an effect of avoidance to vessel noise.

Another brick in the wall: Assessing population structure of Bryde's whales (Balaenoptera brydei) through a multi-method approach.

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Studies with Bryde's whales have suggested population structuring in certain regions. In Brazil, information about the species is scarce, and systematic and broader studies are needed to understand many aspects of its ecology. Thus, we seek to determine the population structure of Bryde's whales in the South and Southeast Brazilian coast, an area with increasing oil and gas exploration. We investigated if there is spatial-temporal structuring driven by coastal and oceanic habitats through multiple and complementary sources of information (habitat use modeling, photo-identification, satellite telemetry, and population genetics). Data collection began in 2015 and was performed regularly by the Cetacean Monitoring Project in Santos Basin (PMC-BS/PETROBRAS) through Line Transect and Telemetry cruises. We recorded 73 groups: 45 groups in coastal waters (<200m), being three groups with calves; and 28 groups in deeper waters (≥200m), being one with calf. The best-fitting model (GLMM) indicated that distribution is influenced by depth, salinity, and minimum surface temperature. We had five resightings of an individual in the same coastal region between 2016 and 2017. One individual was tagged in winter and sent location data for 28 days. This whale remained on the coast for 12 days and then moved to offshore (up to 600m deep), where the signal ended. Extremely low levels of mitochondrial and nuclear genetic diversity were found (n=13), with no differentiation between coastal and offshore whales. Our results point to the existence of a panmictic population, that remain in Santos Basin along the year and uses the region for both feeding and breeding purposes, performing shifts between coastal and continental shelf break habitats. There is also fidelity to some sites. The physio-oceanographic characteristics that drive its distribution are consistent with upwelling events in the region and the shifts between habitats probably reflect changes in productivity and, consequently, in its prey availability.

Causes of death of common dolphins along the Irish coastline 2017-2019

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Strandings of common dolphins (*Delphinus delphis*) have increased year on year along the Irish coast since 2013, especially over the winter period (December to February); an increase out of proportion with other species. Between 2006 and 2010 the Irish Whale and Dolphin Group received 134 records for this species; an average of 27 animals per year. However, in the years 2013 to 2018, this number rose to an average of 84 per year. The cause for the increased stranding rates is unclear, though several cases of suspected fisheries interactions were identified based on post-mortem examinations of animals necropsied during the peak stranding period in 2013. Since June 2017, a cetacean post-mortem scheme funded by the European Maritime and Fisheries Fund and the Irish government has aimed to investigate causes of death in common dolphins, striped dolphins (*Stenella coeruleoalba*) and harbour porpoises (*Phocoena phocoena*). Here, we present the findings for common dolphins. Between June 2017 and April 2019, a total of 72 common dolphins were recovered and necropsied by the Regional Veterinary Laboratory, with oversight by the UK's Cetacean Strandings Investigation Programme (CSIP) at the Institute of Zoology. Necropsies were undertaken in accordance with CSIP's guidelines. Of the 36 common dolphins necropsied between June 2017 and March 2018 for which results are currently available, causes of death were attributed to infectious disease (36%), starvation/hypothermia (22%), live stranding (17%), gas embolism (3%), suspected bycatch (8%), other (8%), or were not established (6%). Preliminary results suggest that

interactions with fisheries were not a significant source of mortality in the observed stranded animals, with incidences of infectious diseases and starvation higher than reported elsewhere.

Long-term bonds: Associations among Atlantic spotted dolphins (Stenella frontalis) off Bimini, the Bahamas.

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Social systems are characterized by the associations and interactions between individuals. For highly social groups such as delphinids, understanding the demographics and long-term association patterns of a population is the first step in interpreting its overall social structure and specific relationships between individuals. This study is the first to investigate the social patterns of a population of Atlantic spotted dolphins (*Stenella frontalis*) off Bimini, The Bahamas, during a 14-year period (2003-2016). We generated association indices and conducted cluster, network, and temporal analyses using SOCPROG 2.8. Dolphins in this group display long-term, year-round residency around Bimini, as well as long-term preferences in association with a combination of rapid disassociation, constant companions, and casual acquaintances. We found no evidence of distinct social clusters within the study group; however, we discovered at least one subgroup with higher association than the rest of the population. This group was composed of male spotted dolphins, which overall tended to associate together more than females and chose companions with similar levels of association to themselves. Despite strong relationships between males, we found no evidence for the existence of alliances or coalitions. Bimini spotted dolphins do not experience the same social forces thought to drive such supportive relationships in other study groups; they do not experience aggressive interactions with sympatric bottlenose dolphins (*Tursiops truncatus*), nor are males limited in their access to females. After defining the close associations between pairs of dolphins, we discuss alternative reasons for close partnerships aside from those seen in other delphinid populations. This study provides a baseline understanding of the social structure of this population that will allow us to investigate the variable relationships between individuals, in addition to exploring the effects of demographic changes within the resident population.

Advances on the ecology, behavior and conservation of franciscanas in northern São Paulo, Brazil, through aerial surveys.

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The franciscana (*Pontoporia blainvillei*) is the most threatened small cetacean in southwestern Atlantic because of the high range-wide bycatch mortality. Since franciscanas are rarely sighted in the wild, knowledge on its social ecology and behavior is scanty. Franciscanas in northern São Paulo, southeastern Brazil, comprise one population known as Franciscana Management Area (FMA) 2a. Here we contribute to the knowledge of some ecological and behavioral aspects of the franciscana in the wild and present abundance estimates for this population. Aerial surveys (twin-engine airplane and helicopter) were carried out from November to January (2010; 2017-2018). Group size ranged from 1 to 6 animals (median=3). Nevertheless, large concentrations of several groups have been recorded, totalizing aggregations of 20-50 franciscanas. The great majority of the mother-calf groups (93%) had 1-3 more accompanying individuals. There is a clear preference for the mother to be in the first position (79%) in these groups, but no lateralization in the position of the calf in relation to the mother (p=0.93) was detected, regardless of the accompanying dolphins. For the first time, franciscana mating behavior was photographically documented, with the male on the bottom position. Feeding behavior was observed, including foraging sprints and rotations. In two occasions, a calf in close association with one adult was recorded to swim away and initiate an association with another adult, suggesting the existence of some degree of extra-maternal care in franciscanas. Contrary to other areas, franciscanas in FMA 2a inhabit very clear waters sometimes associated to rocky shores, from the coastline to the 35m isobath. Abundance in FMA 2a was estimated at 2,040 animals in 2010 (CV=0.42, 95%CI=926-4,495). Although mean annual (2015-2018) stranding mortality in this area is 65 animals (sd=7,8), the lack of bycatch estimates still

precludes a better understanding of the fishery impact on the FMA 2a population.

Convergence and divergence of songs suggests ongoing, but annually variable, mixing of humpback whale populations throughout the North Pacific

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All humpback whale (*Megaptera novaeangliae*) males in a population sing fundamentally the same version of a complex, progressively changing, series of sounds at any one time – the song. The purpose of this study was to describe the relationship of humpback whale populations across the North Pacific based on song composition. Songs were collected from Philippines, Japan, Hawaii and Mexico in 2011, 2012 and 2013. The presence and proportion of 11 phrase types were compared within and between populations to investigate song similarity and change. Results included: shared song phrases across the North Pacific; variable, temporary, regional song differences; varying rate of song change; and distance a factor, but not predictor in degree of similarity. Shared phrases indicate ongoing mixing of populations throughout the North Pacific. Year to year differences in degree of similarity suggest variability in these interactions. Songs appear to diverge as populations split up and converge when they amalgamate. Song studies complicate current US management policy designating four distinct populations in the North Pacific. North and South Pacific humpback whale population structure may be comparable, although song dynamics may be different. The fluidity of song composition suggests it provides acoustic definition or identity to changing associations of whales.

Inner ear morphology of early (toothed) baleen whales (Cetacea: Aetiocetidae) and implications for the origins of infrasonic hearing in baleen whales.

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Understanding the evolution of hearing in cetaceans is crucial to discovering the origins of underwater hearing modalities, and may also help the conservation of extant taxa in the context of an increasingly (and anthropogenically) 'noisy' ocean. While much recent work has centered on modern baleen whales and recent fossils, aetiocetids (Cetacea: Aetiocetidae) – the toothed baleen whale group most closely related to whales possessing baleen – have not yet been examined. Aetiocetids are an essential group to study for understanding the ecologies and origins of modern baleen whale hearing because of this close relationship to modern baleen whales and transitional position representing changes in feeding strategies from using teeth in raptorial feeding to filter feeding with baleen. Here, we perform an in-depth analysis of the bony labyrinth, which can provide data on both ecology and hearing abilities, of an aetiocetid-like taxon. We use microcomputed tomography (microCT) to image and examine two petrosals belonging to adult and juvenile specimens (CCNHM 5402 and 4202) from the Pysht Formation (30.5–26.5 Ma) of Washington, USA. The cochleae are tightly coiled towards the apex, and overall resemble a mixture of features similar to other mysticetes and some odontocetes. Morphological measurements were added to an extensive dataset of cetaceans and other artiodactyls to determine whether this species had similar hearing abilities to modern mysticetes. The semicircular canals and vestibule are also measured and described in detail as they relate to other aspects of ecology; notably, they are relatively smaller than some other mysticetes compared to the cochlea size. Nondestructive microCT scanning approaches provide unique opportunities to better understand the evolution and ecology of aetiocetids, which occupy a crucial position in the evolutionary and ecological history of mysticetes.

From necropsy to 3D reconstruction: How 3D models can help to attract youth into STEM.

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We noticed most of the students had difficulties to imagine the detailed whole organisms and to understand the anatomy on the basis of dissections,

cross sections or book pictures. New and updated teaching techniques would be then required to help the understanding and so to make sciences more appealing to students. It appears 3D modelling is a powerful teaching tool because establishments of models allow highlighting the most important parts of the organisms and scenarios can help to draw attention on the relationships between anatomical parts. A µCT scan, also known as computed tomography scan, makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional images (virtual "slices") of specific areas of a object, allowing the user to see inside the object without cutting it. Once the slices are acquired, the aim is to re-construct the body by keeping the structures of interests (bones, skins, etc.). At the level of the skeleton for example, different bones can be then coloured to underline the different units that form the skeleton. Thanks to an EU-funded project (Marine Mammals Science Education) and collaboration between professors from universities and teachers from high schools, we use 3D animal models to explain precisely the anatomy of marine mammals to pupils and students. µCT scans were realized on harbour porpoise and a harbour seal at the Faculty of Veterinary Medicine (ULiège) to get a closer look at the animal skeleton to highlight the different adaptations (flippers, nares position, elongated skull, cervical vertebrae, etc.) related to their peculiar way of life. The porpoise and seal skulls are compared with human and dog skulls to highlight the common and different features. These 3D animations are also intended to be used by museums to highlight the complexity of marine science for a large public.

Dolphin specialized behavior is resistant to demographic and environmental changes

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Social structure has far-reaching implications for population-level processes, such as the transmission of behavioral specializations among individuals. Social structures and behavioral specializations, however, can be disrupted by changes in population composition and environmental conditions. We examined here how the social structure of a small bottlenose dolphin population (~50 individuals), specialized in foraging with artisanal fishermen in southern Brazil, responded to an abrupt population turnover (30%) and decline in its main prey availability (mullets) in the last 10 years. We found that the population frequency of foraging with fishermen decreased from 0.257±0.197SD in 2007-2009 to 0.144±0.191SD in 2013–2016. The individuals observed in both periods also foraged with fishermen less frequently, indicating that the reduction in the use of the specialized foraging did not result from the population turnover, but instead from reduced mullet availability. Interestingly, the individuals that entered the population in 2013–2016 foraged with fishermen as frequently as the population average, suggesting that they quickly adopted the specialized tactic. The dolphin social structure also changed between these periods. In 2007–2009, dolphins were clustered into social modules (0.240; CI: 0.219–0.237) assorted around the foraging with fishermen (0.457±0.033SE); in 2013–2016 such a social division coupled to the specialized tactic was no longer clear (0.114; CI: 0.118–0.122; 0.195±0.047SE). These results reveal that the social structure is flexible and responds to demographic and resource availability changes. Despite the overall decline in foraging with fishermen, the quick adoption of the tactic by the new dolphins strongly suggests that social learning underlies the transmission of this tactic among unrelated individuals, making horizontal learning key to the resistance of this specialized behavior against the population and social turnover. These findings illustrate the importance of assessing the stability of animal social systems and cultural behaviors in the face of rapid environmental changes.

Toward the identification of important cetacean's areas under threat at a regional scale: The ACCOBAMS Cetacean Critical Habitat's process.

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Countries member of ACCOBAMS and its Scientific Committee are engaged, since several years, in identifying Cetacean Critical Habitats (CCHs), which refer to "those parts of a cetacean's range that are essential for day-to-day well-being and survival, as well as for maintaining a healthy population growth rate".

Important Marine Mammal Areas (IMMAs) in the Mediterranean Sea have been identified during a joint workshop organized by the IUCN Marine Mammal Protected Areas Task Force, in collaboration with ACCOBAMS and the Tethys Research Institute (Greece, October 2016). However, in the context of cetacean conservation and management it is essential to incorporate the concept of actual and/or potential human activities and threats at the population level.

The ACCOBAMS Scientific Committee recommended that in providing advice to the Countries under the ongoing ACCOBAMS threat-based management approach, the concepts of both IMMAs and CCH are considered and incorporated. IMMAs provide an initial biocentric process to be followed by that of the CCHs, in which the spatial distribution of threats is identified, quantified and overlapped to IMMAs. Management advice is then based upon an integration of the two approaches and the prioritization of mitigation approaches on a case-specific basis. This will assist in providing the parties with advice on targeted and effective conservation measures, such as those, *inter alia*, related to mitigating ship strikes.

Using both the IMMA and CCH approaches in the ACCOBAMS region will have a significant added value, since these two concepts reinforce and strengthen each other. Indeed, the global scope of IMMAs will help in promoting awareness and visibility at the international level, while CCHs provide a tool to foster the regional commitment and to revise and update the list of areas of special concern for cetaceans in the ACCOBAMS region, as well as supporting the related conservation and management measures.

Foraging habitat associations of North Atlantic right whales (Eubalaena glacialis) measured using ocean gliders

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North Atlantic right whales (*Eubalaena glacialis*) migrate seasonally into several temperate North Atlantic habitats to feed on dense aggregations of planktonic copepods. Recently a previously unknown foraging area was discovered within the Gulf of St. Lawrence (GSL), a body of water that lies several hundred kilometers north of the known right whale foraging range. Key feeding habitat characteristics, such as dominant prey species, water mass hydrography and tidal current amplitude, appear strikingly different in the GSL relative to other described habitats. This study is the first description of regional environmental associations of right whales in the newly discovered habitat. Between 2016 and 2018 profiling gliders were equipped with hydrophones and conductivity-temperature-depth sensors and deployed continuously between 2 and 6 months per year to measure physical habitat associations of right whales in the GSL. Binary multivariate regression models were applied to these data to explain right whale acoustic presence-absence as a function of variables describing water mass characteristics. Models containing the main effects of temperature, salinity and stratification were selected over a null model containing only static explanatory variables such as bathymetric depth. This demonstrates that dynamic oceanographic processes are important for explaining regional right whale occurrence. The odds of acoustically detecting a right whale each day were twenty times higher in stratified summer conditions than well-mixed conditions typical of the windy autumn period, suggesting a preference for certain seasonally-varying physical processes that affect prey energy density and availability. After accounting for the seasonal effect, right whales were ten times less likely to be detected in warm, fresh water that signifies the regional coastal current, suggesting that right whales target offshore species of copepods such as *Calanus* spp., as opposed to coastal species, in this habitat. This study identifies key spatiotemporal constraints on right whale occurrence and demonstrates the use of gliders as tools to study whale-habitat associations.

Behavior-based association patterns in common bottlenose dolphins (Tursiops truncatus) in Boca Ciega Bay, Florida

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Common bottlenose dolphins (*Tursiops truncatus*) in Boca Ciega Bay, Florida live in a complex, fission-fusion society where group membership and

size change frequently. As dolphins display high behavioral plasticity, changes in behavioral state can potentially influence group size and composition. Individuals may require stronger associations when engaging in cooperative behavior, such as group foraging, than when individuals are competing for access to limited resources. This study examines the association patterns of common bottlenose dolphins in Boca Ciega Bay, Florida, in four different behavioral states (foraging, socializing, travelling, milling).

Photo ID and group behavioral data records were collected during 2011-2015 as part of the ongoing research conducted by the Eckerd College Dolphin Project, and were analyzed using SOCPROG social analysis software. Permutation tests, comparing observed association patterns to random datasets, revealed differences in association patterns between the different behavioral states. Significant preferred associations were revealed in all behavior states except for foraging; which fits with the lack of observations of cooperative foraging in this area. Standardized lagged association rates were determined within each behavioral state to investigate differences in the temporal patterning of associations. Travelling and milling association rates showed preferential associations over time, while socializing and foraging association rates did not. This study provides insight into the role that ecology plays in the evolution of these social structures, especially when compared with similar studies conducted on other populations of common bottlenose dolphins in Cedar Key, Florida and in Shannon Estuary, Ireland, as well as Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Australia.

Bridging the gap between visual and acoustic data for north Atlantic right whales.

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North Atlantic right whales (NARWs) are one of the most endangered, but well-studied cetacean populations in the world. Dedicated NARW survey efforts have amounted to long-term visual and acoustic datasets across their western North Atlantic range. Management primarily focuses on visual data to determine NARW habitat, as they provide an estimate of the number of animals present from surface observations in a given location. While NARW visual data is robust, reliable, and dates back to the 1970s, data collection is limited by weather conditions, daylight, and survey range with most effort historically occurring during summer months. Over the last 15+ years, passive acoustic monitoring (PAM) has emerged as a complementary and effective way to determine NARW presence. PAM can provide continuous, year-round coverage of a broad area at comparably low costs, but it cannot be used to determine the number of individuals present, or to identify non-vocalizing animals. Both visual and acoustic data exist spanning the southern NARW calving grounds off Florida, USA to northern feeding grounds off Nova Scotia, Canada. To date, these datasets have been used independently of one another. This study uses an occupancy modeling approach to merge visual and acoustic data together, combining the breadth and limitations of both data sets, to provide better estimates of NARW occupancy throughout their range, across seasons and years. Visual data (1992 to 2016) from Roberts et al. 2016 and acoustic data (2004 to 2018) from Davis et al. 2017, with recent additions to both datasets, were combined into 10km spatial grids and subsequently overlaid into occupancy models using RPresence. These results are a first attempt to fill in information gaps by using both data types together, providing a better understanding of important areas for a critically endangered species, and an alternative method for predicting long-term changes in occupancy.

Stable isotopes of sea lion whiskers reflect impact of ocean warming on diet.

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Marine biological processes are dependent on dynamic, seasonal trends in temperature. Observed and projected periods of oceanographic warming have the potential to drastically alter basic oceanographic dynamics. These changes impact upper trophic level predators significantly, making changes in their population parameters during environmental change an indicator of overall ecosystem state or condition. California sea lions are abundant predators that occupy the California Current System and whose weaning and reproduction are significantly impacted by the changes in primary productivity and concurrent shifts in their prey that occur during anomalous temperature events. By monitoring changes in sea lion diet through stable isotopes deposited in inert tissues in their whiskers, I plan to construct a dietary timeline across 30 adult females, providing a continuous dietary analysis across a temporal range of environmental conditions. Retrospective analysis of diet on an individual level can provide

insight into the long-term effects that an increasingly warmer ocean can have on predators and on trophic interactions.

The lesion profile of cetaceans diagnosed with neurobrucellosis in Scottish waters 1991 to March 2019.

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Brucella ceti was first reported in the early 1990's and has since become an important pathogen in cetaceans worldwide. Possibly the most important disease manifestation is *B.ceti*-associated meningoencephalitis or neurobrucellosis in cetaceans. In Scotland, *Brucella* sp. have been isolated from eleven species of cetacean and *B.ceti*-associated meningoencephalitis in seven. In this study, we re-examined historical cases for gross and histological evidence of neurobrucellosis and, along with new cases, neurological lesion profiling was performed to determine differences and/or similarities between cases and sequence types. New cases with gross lesions suggestive of neurobrucellosis had their whole spinal cords removed for histological examination. Histological sections of brains from defined areas were blinded, and scored from zero to five; zero being no lesions present and five being severe lymphocyte infiltration and/or perivascular cuffing, lesions typically associated with neurobrucellosis in cetaceans. Analysis showed that lesions in most cetacean species occur in the meninges and increase in severity from rostral (cerebrum) to caudal (medulla) and lesions in the brain parenchyma follow a similar pattern. Lesions in the brain parenchyma were more common in animals with a more severe meningitis. Cases of neurobrucellosis were more common in pelagic delphinids, particularly striped dolphins and Atlantic white-sided dolphins, but absent in other species, such as white beaked dolphins, despite similar numbers being examined and this warrants further investigation. Cases also occurred in Sowerby's beaked whales and a novel case of meningoencephalitis in a single minke whale with dual *Brucella pinnipedialis* and herpesvirus infection. These findings suggest that pelagic delphinids are more susceptible to *B.ceti*-associated meningoencephalitis and this should be a differential diagnosis for any live-stranded cetacean.

Effect of boat activity on the acoustic communication of bottlenose dolphins (Tursiops truncatus) of Dolphin Bay, Bocas Del Toro, Panama

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Bottlenose dolphin whistles play an important role in their communication. There are two types of whistles: (1) variant whistles that are used by all dolphins for group cohesion when traveling, foraging and socializing; and (2) signature whistles, which are unique to each individual and are used to maintain contact between specific group members (e.g. mother-calf). Given the role whistles play on dolphin communication and behavior, here I study the impact of boat activity on the emission of whistles types, the context, and the whistle acoustic structure. Recordings were obtained from multiple years using broadband recordings systems deployed from boats and recently deployed autonomous recordings systems at the Bocas del Toro in Panama. Using both active and passive recordings allowed for the behavioral context of some whistles to be known, as well as for 24-hour examination of whistle emission. A total of 1,635 whistles were analyzed with 1,145 being identified as variant and 490 as signature, following the Signature Identification (SIGID). Variant whistles were more common independently of behavior or boat presence. In terms of acoustic structure, the two type of whistles are significantly different from each other, with signature whistles been more complex than variants with longer durations, broader frequency ranges, and more modulation. In the presence of boats, signature whistles showed a narrowing of their frequency range most likely a strategy to avoid potential masking by boat noise. Our study shows that when studying the impact of noise associated to boat traffic on dolphin whistle acoustic structure is important to differentiate between variant and signature whistles.

Nature vs nurture. Echolocation clicks of Sotalia fluviatilis and Sotalia guianensis; Sister species in contrasting environments.

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Successful toothed whale orientation, navigation, and foraging is dependent on the key sensory modality of echolocation. Biosonar signal characteristics determine an echolocating animal's sensory volume and have allowed species to adapt to unique foraging niches. Yet, the evolutionary drivers behind odontocete biosonar parameters remain poorly understood. Recent studies have shown that source parameters are related to body size and have also highlighted the possible influence of habitat. However, only a few studies have compared the biosonar characteristics of closely related species in different habitats, raising questions on the extent to which habitat shapes source parameters. Here we use the two *Sotalia* species, *fluviatilis* and *guianensis,* to test the hypothesis that habitats shape biosonar parameters by comparing source parameters among these sister species in different environments. Using the same seven-element vertical hydrophone array, *S. fluviatilis* were recorded in the deep channels and open areas of the Rio Negro in the Amazon River and *S. guianensis* in the entrance to the coastal Guaraíra Lagoon in Tibau do Sul, Brazil. *S. fluviatilis* produced biosonar clicks with a mean source level of 199±4 dB re 1µPa pp, mean centroid frequency of 126±7 kHz with inter click intervals (ICIs) of 52±22 ms. This marks a considerable difference from the low amplitude and short ICI biosonar of the sympatric boto, *Inia geoffrensis geoffrensis,* commonly found in the shallow narrow channels of the river. In contrast, *S. guianensis* used biosonar clicks with 194±7 dB re 1µPa pp, mean centroid frequency of 117±13 kHz and ICIs of 43±26 ms to navigate the shallow and narrow entrance to the lagoon, which is closer to the biosonar characteristics of *Inia g. geoffrensis.* This study affirms the influence of habitat on biosonar source parameters and the dynamic plasticity of delphinid biosonar which has allowed for adaptations to diverse foraging niches.

Changes in bottlenose dolphin immune functions associated with the deepwater horizon oil spill in the northern Gulf of Mexico, a recurrence?

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The explosion of the Deepwater Horizon platform in 2010 resulted in an unprecedented release of oil in the Gulf of Mexico. Comprehensive health assessments were conducted on bottlenose dolphins in Barataria Bay, LA (BB), in 2011, 2013, 2014, 2016, 2017 and 2018, to assess potential health effects resulting from exposure to oil. Results were compared to those for Sarasota Bay, FL (SB), dolphins not exposed to oil (sampled in 2011, 2012, 2013, 2014 and 2018). We previously reported significant increases in T lymphocyte proliferation, as well as lower Th1 cytokines IL-2, IL-12 and IFNg, lower Th2 cytokines IL-5 and IL-13 but higher IL-4, and lower Treg cytokine IL-10, in BB 2011 compared to SB, with values returning to "normal" in 2013, 2014 and 2016. These changes in immune functions were generally similar to those in the relatively few studies in other species upon exposure to oil in particular or PAHs in general, and consistent in time and space with exposure to oil from DWH. Interestingly, results from health assessment captures in BB in 2017 and 2018 showed a recurrence of increased T cell proliferation and a cytokine balance tilt towards a Th2, rather than Th1 or Treg response, as was observed in 2011. Further exploration showed that dolphins born after the spill appeared to exacerbate this trend, suggesting the possibility that dolphins born after the spill would suffer the negative health consequences of exposure to oil. These observations could be explained by either transgenerational effects on the developing fetus, continued exposure to oil in BB dolphins, or a combination of both. Our study highlights the need for assessing subtle, sub-clinical aspects of health to understand potential ongoing and future consequences of exposure to oil spills.

International and multidisciplinary network for the preservation of the good environmental status of the marine areas of Macaronesian region and the conservation of their cetacean populations (SANICET)

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Macaronesian Region is an important biodiversity hotspot located in the North Atlantic Ocean, between Europe and Africa, conformed by four archipelagos (Azores, Madeira, Canary Islands and Cabo Verde Islands). Among the species that inhabits this area, cetaceans occupy a remarkable place in terms of abundance and diversity, having confirmed the presence of 32 different species residing or transiting their waters.

Macaronesian Cetacean Health Network (SANICET) was conceived with the objective of carrying out a program of health surveillance of Macaronesian cetacean populations or, in other words, to assess and monitoring those possible risk factors or threats that could affect, directly or indirectly, the conservation of these cetaceans. Diverse scientific groups specialists in cetaceans that usually work in this Region, in different areas of knowledge: animal health, ecology and oceanography, joined efforts to integrate and harmonize procedures and knowledge from a multidisciplinary and interregional point of view, connecting them up into a powerful ICT tool of recent creation, a Collaborative Virtual Community (CVC) which shares data, information and methods, overcoming territorial and border fragmentation in the cetaceans conservation.

This initiative took shape through the MARCET Project (Interreg-MAC 2014-2020), in which the scientific studies proposed are directed towards the management for the preservation of the good environmental status of Macaronesian marine areas, the conservation of their cetacean populations and the promotion of a sustainable ecotourism model, mainly related to Whale Watching activity.

Using citizen science to investigate marine mammal occurrences and respond to strandings in the Negros Occidental Coastal Wetlands Conservation Area, Philippines.

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The Negros Occidental Coastal Wetlands Conservation Area is the Philippines' 7th Ramsar Site of Wetlands of International Importance. It consists of 23,000 ha of coastal wetlands which include the municipal waters of 10 cities and municipalities of Negros Occidental and are part of two major marine bodies: the Guimaras Strait and Panay Gulf. Its biodiversity include 72 recorded species of migratory birds and the economically important nylon shell (*Paphia undulate*) and angel wings seashell (*Pholas orientalis*). Despite its economic importance to the fishing community, little attention has been given to large marine

vertebrates such as marine mammals, turtles, and whale sharks. In 2010, interview surveys by Dolar et al. (2011) led to the discovery of the Philippines' second population of Irrawaddy dolphins (*Orcaella brevirostris*) in one of the coastal areas of NOCWCA. Since then, the awareness on marine mammals have led to heightened vigilance on sightings and response to stranding events, especially with the recent establishment of the Negros Occidental Coastal Wetland Area Management Alliance (NOCWAMA), an alliance of environmental managers tasked to foresee the sustainability of the wetlands. The Alliance also recognized the role of the academe in providing scientific data to contribute to management-related decisions. In 2017, a marine mammal and whale shark stranding response and rescue training was conducted to strengthen the NOCWAMA's conservation capabilities and to effectively collect and report data as well. This study utilized fisher interviews to investigate the occurrences of other marine mammals that are often sighted by municipal fishers when going out to sea, or during stranding events. The study resulted in mapping out potential sites for further investigation, including habitats for endangered dugong and Irrawaddy dolphins.

Environmental factors related to group size and habitat use of Guiana dolphins from São Marcos Bay, northeast Brazil

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Environmental changes can affect the social structure and disrupt habitat use of marine mammal species. An impact on the social dynamics of dolphins, including group size structure, may attenuate the feeding success and increasing predation risk, especially considering species exhibiting small home ranges, which impose particular habitat dependency and high vulnerability to environmental changes. In this regard, the Guiana dolphin, *Sotalia guianensis*is a particularly endangered species due to its coastal distribution considerable small home range. The aim of this study was first to conduct a spatial assessment of the dolphin groups sighted during a fieldwork conducted in the São Marcos Bay (SMB; Northeastern Brazil), one of the most import port areas from Brazil, from where about 120 millions tons of diverse mineral are annually transported worldwide. The results show an overlap between the distribution of the dolphin groups and the port activities area, which includes the loading zone at main port area and the navigation channel used by large cargo ships and other vessels. Also, a Generalized Linear Modeling approach (GLM) was conducted in order to identify the best combination of selected variables that best predict the group size of the dolphins. The predictor variables included: salinity, se surface temperature, depth, water transparency, distance from the main port area, and the feeding activity of the groups sighted. The results indicated that larger dolphin groups were found in areas closer to the main port area and were associated to foraging activities. Therefore, the results suggest that this dolphin population might be exposed to threats linked to the port activities, which may include noise pollution, vessel collision and chemical pollution. This study opens a scientific avenue for exploring the effect of potential anthropogenic threats on the Guiana dolphin population at the SMB.

Bycatch, consumption and trade of Burmeister's porpoise (Phocoena spinipinnis) inshore Peruvian southern waters

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It was estimated that in 1990-1993, 15-20,000 dolphins and porpoises were caught in Peruvian artisanal fisheries. In 1996, a national law banned dolphin and porpoise capture and trade. However, a study with onboard observers in the artisanal fishery resulted in very high mortality rates (levels) of four species of small cetaceans, among them, Burmeister's porpoise (*Phocoena spinipinnis*).

Here we presented preliminary results of an ongoing observer program in artisanal gillnet fishery from Tambo de Mora (13° 30' S, 76°11' W) and San Andrés (13° 43' S, 76°13' W), southern Peru. Objectives are: 1) characterize and quantify capture of small cetaceans, 2) sensitize and increase awareness about small cetaceans among fishers and fishing authorities.

On-board observations were registered in surface gillnets and bottom set gillnets. The target species were eagle ray (*Myliobatis peruvianus*), guitarfish (*Rhinobatos planiceps*) and whiptail stingray (*Dasyatis brevis*), among others. Vessels operated from 0.5nm to 5nm and the characteristics of nets were 145m – 182m of length, 9-11 m of height, 12"- 14" of mesh size with 10-15 nets, totalizing 1.85 to 2.22 km of the net. Based on 56 fishing trips during the period of January 2015 to March 2019, the estimated CPUE for Burmeister's porpoise was 0.82 animal/trip^{-1}. Small cetacean

capture composition was 95.8 % porpoises and 4.2 % dusky dolphin and with a 95.75 % recovered dead and 4.3% alive from the nets. Small cetacean meat was used for fisher's consumption or trade; the meat was sold US$0.60 – US$1.5 /kg and is consumed fresh or processed as *muchame*, a dried local dish.

Different approaches were identified for monitoring and reducing cetacean bycatch: 1) socioeconomic and market studies, 2) incorporate devices to avoid incidental captures, 3) sensitize and develop campaigns for reducing demand for small cetacean meat and 4) enforcement of the law.

Movements of common bottlenose dolphins (Tursiops truncatus) within the Pelagos Sanctuary (North-Western Mediterranean Sea).

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Common bottlenose dolphin (*Tursiops truncatus*) research and conservation actions were implemented in the Pelagos Sanctuary, the largest marine protected area (87,500 km^2) for Mediterranean marine mammals, within the framework of project "Dolphins Without Borders", Studies were conducted in three areas with a water surface, respectively (west to east), of 11,000, 2,200 and 8,150 km^2, between Nice and Elba Island. During 203 visual surveys, totaling about 8700 km of research effort under positive conditions (sea state < 4 on the Douglas scale), bottlenose dolphins were sighted 101 times. The unified photo-identification catalogue resulted in a total of 185 well-marked individuals.Of these, 53 (28%) matched with at least one of the other two catalogues. Only 2 dolphins (1%), both mother/newborn pairs, sighted between July and September 2018, were included in all the three catalogues. The maximum displacement distance was measured for each dolphin sighted at least twice (n=143): mean and median displacements were respectively 105, and 81 km, with 20% of the dolphins showing a displacement higher than 188 km, while the maximum displacement recorded was 272 km. These movements are longer than those reported in a similar study carried out in the same area, suggesting a possible extension of the dolphins' home range over time. The photo-ID data collected within this project were also matched with those collected along the French Mediterranean coast and Corsica within the GDEGeM project (2014, 381 individuals), resulting in only 4 matches, all involving individuals moving between Liguria and the eastern portion of the French coast. This result seems to confirm that there are quite stable discontinuities in the connectivity of the Pelagos bottlenose dolphin network, in agreement with previous studies.

The unprecedented sensitivity of the external ear canal of odontocetes, evolutionary adaptation, functional morphology, and histopathology

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Over the course of evolution, the odontocete hearing apparatus has undergone major adaptations with the development of alternative hearing pathways. As such, the external ear canal lost its function as sound conductor but still constitutes active components such as glands, muscles, an intense vascularization, and sensory nerve formations[1]. Although the function of the ear canal was subject to debate in early cetacean research, it got neglected as focus was put on other structures, and its significance remains a conundrum heretofore. In this study, we analysed the ear canals of various odontocetes (incl. striped dolphin, bottlenose dolphin, common dolphin, harbour porpoise, long-finned pilot whale, and Cuvier´s beaked whale) using macro- and microscopic techniques to study morphology and pathology. Results indicate that the ear canal has acquired an unprecedented sensitivity that could function as an extero- and proprioceptive pressure sensor. We describe mechanoreceptors, identified as simple lamellar corpuscles in all of the odontocetes, while absent in terrestrial mammals, which show

morphological resemblance to the inner core of Pacinian corpuscles as shown by immunohistochemistry, transmission electron microscopy, and immunofluorescence and confocal microscopy. The receptors form part of a complex nervous network that surrounds the ear canal in its superficial half, while it is concentrated into a ´sensory ridge´ in the medial half, associated with cartilage, vascular lacunae, and the tympanic membrane. We provide a preliminary hypothesis that the ear canal has an essential role in the correct functioning of the hearing apparatus. And finally, we describe various pathologies, including purulent otititis externa and granulomatous dermatitis with hyperplastic pigment-laden macrophages, which could negatively affect those functions, and/or could serve as indicators for infectious diseases and other causes of death. These results provide essential information for a better understanding of the sensory system of cetaceans, functional morphology of the hearing apparatus, and associated pathologies.

Feeding of humpback whales (Megaptera novaeangliae) in Nicaragua, Central American Breeding ground.

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We report evidence of feeding by humpback whales in the Central American subpopulation of this species along the Pacific coast of Nicaragua during their winter breeding seasons in 2017 and 2018. Boat-based surveys were conducted to collect data on whales as part of ongoing studies at two field sites: Northern and Southern Nicaragua. We documented 18 events with either direct or indirect evidence of whale feeding activity, exclusively in Southern Nicaragua. Lunge feeding was observed on 6 occasions and in 12 sightings there was indirect evidence of feeding including the erratic surface movements, the presence of feces, and close associations with feeding aggregations of seabirds and dolphins. Photo-identification analysis revealed that at least one whale was documented feeding in both years, indicating some whales may regularly feed in this location to account for the energetic demands of migration. These findings provide important insights into the importance of Nicaragua for migrating humpback whales.

Numerical modeling tools investigating marine mammal lung and melon response to underwater explosion impulse

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Marine mammals could be exposed to underwater explosions (UNDEX) in various settings, including coastal construction, underwater demolition, and military operations. Primary blast injury (PBI), the gross blast-related trauma or traces of injury in air-filled tissues or tissues adjacent to air-filled regions (e.g. lungs, GI tract), has been documented in a number of marine mammal species after blast exposure. The melon, an important component of echolocation, if damaged, may compromise an animal's ability to navigate, communicate, hunt, and ultimately survive. Little is known about marine mammal susceptibility to PBI, and even less about potential UNDEX damage to the melon. As a result, traditional analysis relies on methods developed almost 40 years ago using terrestrial mammals as surrogates for marine mammals in experimental protocols, ignoring species-specific physiological adaptations to the marine environment. Currently available numerical modeling tools (finite element modeling and computational fluid dynamics) could better inform zones of influence estimates for UNDEX by simulating the response of morphologically accurate proxies with material properties representative of marine mammal tissues. We developed a computational model of a surrogate air-filled spherical membrane structure subjected to directional shock loading to represent the full complexity of *in vivo* marine mammal lung and melon response to UNDEX. This approach incrementally improves the assumptions used by the US Navy, which employs a surrogate of a one-dimensional spherical air bubble of equivalent lung volume for a given marine mammal species, with the bubble oscillating in response to an initial velocity and omnidirectional pressure loading. For the melon, we are developing similar surrogate models to determine potential damage to melons at UNDEX impulse/peak pressures below what would cause severe lung hemorrhage (e.g., death). Verification and validation testing were conducted for the various surrogate models investigating marine mammal lung and melon dynamics.

Oh what a tangled web we weave- bycatch in UK stranded cetaceans

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The collaborative Cetacean Strandings Investigation Programme (CSIP) has been funded by UK government since 1990, to provide a systematic and coordinated approach to the surveillance of UK stranded cetaceans and to investigate causes of mortality. In the 29-year period between 1990 and 2018, the CSIP received reports of 15814 cetaceans, of which 13956 were dead strandings, 1155 live strandings and 703 found dead at sea. The CSIP investigated 4039 cetaceans through systematic necropsy during this period. Of these, 764 were diagnosed as having died due to incidental entanglement in fishing gear as non-target species (bycatch), making this the primary direct anthropogenic driver of mortality in UK stranded cetaceans. Bycatch or entanglement was diagnosed as a cause of death in 14 of the 19 cetacean species examined in the UK. Bycatch was most frequently diagnosed in harbour porpoises (*Phocoena phocoena*, n=374, or ~15% of examined cases) and short-beaked common dolphins (*Delphinus delphis*, n=329, or ~42% of examined cases). Frequently observed external pathologies included epidermal netmarks or ropemarks, penetrating wounds to the body wall, excised fins or flukes or other evidence of trauma consistent with fisheries interaction. Bycaught animals were generally in good nutritional condition, had evidence of recent ingestion of prey and other significant factors were eliminated. Southwest England appeared to be a bycatch hotspot in the UK, with 436 diagnosed cases. Bycatch was also strongly seasonal, with 418 cases recorded stranded during the quarter January-March. Bycatch has been a consistent finding every year since the inception of the CSIP in 1990. The welfare implications of bycatch at an individual level are clear from this study. Bycatch can also represent a significant conservation pressure, particularly in small, fragmented or isolated populations. More efficient integration of regional and global efforts is needed to improve mitigation of this significant cetacean threat.

Dietary and isotopic niche overlap between three Arctic phocids in Hudson Bay, Canada.

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The sub-Arctic marine environment of Hudson Bay is home to three species of phocid seals: ringed (*Pusa hispida*), bearded (*Erignathus barbatus*), and harbour (*Phoca vitulina*). As climate warming leads to changes in prey distribution, these three species may experience greater dietary niche overlap and resource competition.We investigated spatiotemporal shifts in seal dietary niche overlap and composition to test the hypothesis that these seal species occupy similar ecological niches, particularly ringed and harbour seals. We used stable isotopes and lipid biomarkers from tissues sampled in the fall by Inuit hunters from 2003–2017 in Arviat (west) and Sanikiluaq (east), Nunavut. Long-term analysis of Arviat isotopic niche size using muscle tissue indicated ringed seals (n=537) overlapped with harbour (n=22) and bearded seals (n=43) by 41% and 36%, respectively. However, shorter-term analysis using liver tissue indicated increased overlap to 63% between ringed and harbour seals, and a decrease to 33% between ringed and bearded seals. In Sanikiluaq, ringed seals (n=543) overlapped with bearded seals (n=37) by 47%. Bayesian mixing model diet estimates were similar for ringed and harbour seals, revealing that sand lance and capelin fish were the primary prey, whereas bearded seals consumed primarily sculpin fish and benthic invertebrates. Highly branched isoprenoid index (H-print) from seal liver was used to distinguish pelagic and sympagic carbon sources. Ringed seal H-print was 62%, indicating a pelagic-sourced carbon diet, compared to harbour seal H-Print, 31%, a more sympagic-sourced carbon diet. However, ringed and harbour seals had low absolute concentrations of IP_{25} (18.1 and 10.1 ng/g respectively), suggesting considerable contributions of freshwater sourced carbon in their diets. While dietary and isotopic niche overlap appeared to be

high, lipid biomarkers revealed specific prey differences suggesting niche partitioning. Our observations provide an improved understanding of how these three phocid species are utilizing resources, which provide insight into the structure and function of this sub-Arctic marine system.

Precision-cut adipose tissue slices: A novel approach to study adipose function under multiple stressors in marine mammals.

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Marine mammals are increasingly exposed to multiple anthropogenic stressors (pollution, decrease of food quantity/quality, disturbances linked to sonar, oil drilling, boat traffic and coastal development), which are likely to exert an effect on adipose tissue development and function. The disruption of this essential endocrine organ can have deleterious consequences on the organism health and survival. We have developed and validated a novel approach of precision-cut adipose tissue slices from northern elephant seal (NES – *Mirounga angustirostris*) to determine *in vitro* the impact of multiple stressors on adipose function. Blubber biopsies were taken on free-ranging NES from the colony of Año Nuevo (California). We distinguished two layers in the blubber (outer and inner) and two periods of fasting (early and late). Blubber biopsies were cut into 1mm thick slices that were kept in culture media at 37°C. Slices weight was 4.75 ± 1.49 mg and followed a normal distribution. Slices viability was good during at least 3 days of culture. Slices response to metabolic stimuli was assessed by triggering lipolysis with isoproterenol, either at day 0 or at day 2 of culture. Tissue slices in the lipolytic condition released significantly more glycerol than tissue slices in the non-lipolytic condition, even when the stimulus was induced after 2 days of culture. The concentration of glucose in the culture medium did not affect the efficiency of lipolysis and the response to lipolytic stimulus did not vary between outer and inner blubber. The release of glycerol from inner blubber was higher at early as compared to late fast. In conclusion, this model is ready to be used to study the impact of pollutants and other stressors on adipose tissue biology. For that purpose, we are currently exposing the precision-cut slices to compounds mimicking a physiological hormone stress-response and/or an exposure to environmental pollutants.

Camera-trap surveillance of the endangered Mediterranean monk seal in the Gökçeada Island, Northern Aegean Sea, Turkey

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Gökçeada Island is one of the important Mediterranean monk seal (*Monachus monachus*) habitats in Turkey and existence of the monk seals has long been well known on the island. There are only six different caves or haul-out sites on the northwestern coast which are convenient for monk seals. This is the first study aims to obtain data on individual identification and number of seals, yearly distribution and frequency of habitat usage and environmental parameters affecting monk seal presence. The preliminary findings of four months of monitoring period between 21 June to 21 October 2017 of two caves and one haul-out site were analysed. Out of 123 monitoring days seals were photographed on 40 days in haul-out site, 23 and 31 days in caves, respectively. Clear diel pattern was observed for the haul-out site rather than the caves. Totally five individuals (adult male and female, two young and one newborn) were detected. In one sighting, five seals were photographed together in a cave. A newborn pup and nursing behaviour/lactation was observed in the first week of October 2017. The longest duration without leaving cave recorded as 43 hour. Monitoring study still in progress together with collecting environmental and anthropogenic parameters (fishing, tourism, sea state etc.) to understand the current situation of these seals using the island, consequently to elaborate better conservation strategies for the survival of this species in the region.

A focal animal 6-points Likert scale to rate intra-unit interactions in sperm whales

(Physeter macrocephalus) off Mauritius Island.
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Female sperm whales (*Physeter macrocephalus*) and their offspring live in stable and matrilineal social groups called units, characterized by stable long-term social relationships. Most females stay in their natal unit while juvenile males disperse before maturity and aggregate with other young males in bachelor schools. In 2011, a project was launched under the Authority of Marine Megafauna Conservation Organization to study sperm whales off Mauritius Island. To date, ninety eight sperm whales are identified using their markings, scars and color patterns: 17 large males, 65 adult females and 16 juveniles belonging to at least 5 units. In order to understand the intra-units' social dynamic and to rate the different types of interactions, we created a social scale following a focal animal 6-point Likert scale that ranges from 1 (the weakest) to 6 (the strongest): 1) individuals seen the same day but hours and miles apart, 2) individuals seen at the same time but >100m apart, 3) > 2 individuals without physical contacts but in visual range (< 20m), 4) socialization: > 2 individual with physical contacts, 5) dyadic interaction and 6) nursing. We added sub-criteria to enrich this scale: for instance 3 and 4 are respectively subdivided into 3a) sleeping and 3b) swimming; 4a) juveniles with adults and 4b) juveniles together or with a nursing female. Five comprised dyadic interactions with (5a, b, c) and without (5d, e) physical contacts, and 6 comprised 6a maternal nursing and 6b allonursing. Aerial observations and underwater videos were carried out from February to May from 2013 to 2017, and from February to August in 2018 for a total 250 hours of audio-video data. After presenting and explaining in details the scale, its sub-criteria and the obtained matrix, we discuss the benefits and pitfalls of using a Likert scale when interested in wild marine

Precocious echolocation ontogeny and click development in the harbour porpoise (Phocoena phocoena).
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Despite echolocation being a highly specialized key sense for odontocetes, fundamental for their survival, little is known about sound production and echolocation ontogeny. To investigate this, we studied 3 harbour porpoise calves born in captivity from birth until up to an age of 9 months. Hydrophone array and synchronized video recordings were used to perform acoustic localization of each click, to determine source parameters of the calves' sound emissions. Immediately after birth, all calves emitted high frequency clicks suitable for echolocation. On-axis calf clicks resembled the adult signals but had a broader high-frequency content with higher mean centroid frequency (145KHz) than adults (125kHz), and a simultaneous low-frequency component at 2.3kHz stronger than in adults. Two days postnatal, the calf regulated the intensity of its calls, decreasing click intensity when approaching a target, equally to echolocating adults. Two days post-natal the calf maintained the intervals between clicks above the two-way travel time, as adults do. Four days post-natal, the calf controlled the click emissions rate, decreasing the inter-click interval when approaching the target, indistinguishably from adults. This show that active echolocation and the inferred processing of the echoes is developed within four days post-birth, which makes harbour porpoises the fastest developing echolocator studied so far. Changes in the high frequency content of the calf clicks were observed throughout nine months. This can be explained by the size increase of the sound-producing organs. The long-term changes in the click parameters (duration, frequency centroid and bandwidth) allows for acoustically ageing of individuals, which were different from adults up to 9 months old, close to the weaning time of porpoises. This hints at the possibility of using the click parameters to detect the presence of lactating calves in the wild, allowing specific conservation measures for porpoises during this vulnerable period of their lives.

Vantage points survey of the Black Sea harbour porpoise (Phocoena phocoena ssp. Relicta) in Bulgaria.
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During 2015, the Black Sea Harbour Porpoise at vantage point survey located in 6 regions along the Black Sea coast of Bulgaria (Agalina, Durankulak, Emine, Kamchia, Nessebar and Sinemorets) have been made. For each area, the survey lasted 20 days. The real data have been collected during 06. 2015-07.2015 period. As a result, it was found that the species is distributed throughout the all coastal aquatory. The species is observed singly or in groups of 1 to 7 individuals, on average - 3.05 individuals in a group, most often 1 individual. The largest number of individuals were registered in July - 111 from Cape Emine. This determines this area as the most important for the coastal waters for the species. From the total of all 6 points, the species have been registered in 146 observations with a total of 289 individuals, of which 146 individuals in June and 143 individuals in July. In the period August 2016 - August 2017, year-round field observations were carried out from a vantage point in Varna Bay. This Survey covers 66 field days and 330 hours. The observations of the species were 80 and registered individuals - 119. All registrations were in the northern part of the bay, no more than 364m from the coast. The registrations of the species fall into a one-UTM square - NH78, 74. The detailed analysis of the favorable period of observation (April-July) shows that in Varna Bay the highest number of individuals was observed in July 2017. - 32 individuals. In the months of May, June and August of 2017, high rates were also recorded: 23, 26 and 23 individuals, respectively. This indicates that the favorable observation period also includes August.

Improving behavioral studies of wild cetaceans with an Android device

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Once a contact with wild cetaceans is obtained under good weather conditions, field behavioral studies are particularly difficult to carry out due to the highly dynamic nature of variables. Even in a simple case, such as a single sperm whale surfacing and blowing before its next dive, variables seen as secondary may be missed if data recording is conducted on a paper form. In a complex case, such as long lasting focal follow of a dolphin school, large amounts of data are lost due to our limited capacity to collect information flows on variables such as school structure variations, sub-group movements and surface behaviors, responses to approaching vessels, etc.

GREC developed and tested an Android software, named PADOC (Plateforme d'Acquisition de Données d'Observations Cétologiques) to overcome data collection limitations in field behavioral studies.

PADOC was developed to run on virtually any Android device. It uses GPS and compass sensors if available. It is designed to be easily handed over to part-time researchers.

PADOC allows to record different data types such as group structure, cetacean movements and positions (speed, course), and surface events (jumps, blows, social behavior, etc.). Time and position are automatically recorded with any entered data, and a CSV file is generated so that the data can be easily processed later.

During 2018, behavioral data was collected with PADOC in simple and complex situations: for example, during a 6.5 hour sighting of two sperm whales, each animal's surfacing and fluking times, blowing rates, were collected together with their respective positions and movements.On another occasion, PADOC enabled to store 336 events during a 2.1 hour sighting of a bottlenose dolphin school, including 55 surface events and 9 interactions with recreational boats.

Following initial field tests, PADOC is now ready to be released to field researchers for wider experimental use.

A dramatic decrease of Risso's dolphin presence off French Riviera

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Over the three last decades, regular small boat surveys held year round off Antibes, French Riviera, enabled to monitor the presence of the Risso's dolphin (Grampus griseus). A total of 37 sightings were obtained from 1989 to 2010 in a study area between Cap Camarat and Cap Ferrat, to 20 miles offshore. Total effective effort amounted to 27580 km. Risso's dolphin were observed during all seasons, being more frequent in winter and spring once effort was accounted for. Sightings were located from shelf to deep slope waters

(>2000m depth), with a trend to be farther offshore during winter. Mean school sizes were stable over the period (9.16, SD=7.13). We estimated average sighting rates (ASR) for three consecutive 10-year periods: 1989-1998, 1999-2008 and 2009-2018. Sample unit was one year. ASR was 0.226 ind./100km (SD=0.185) for 1989-1998, 0.114 (SD=0.112) for 1999-2008, and 0.015 (SD=0.045) for 2009-2018. Not a single sighting was obtained after 2010. Even if yearly sighting rates were irregular, with high values of 0.615 ind./100km in 1996 or 0.428 in 1993, the decreasing trend is further materialized by the frequency of '0 sighting' years: one for 1989-1998 and 9 for 2009-2018. Recent literature includes large scale aerial survey reports showing several Risso's dolphin sightings well in the oceanic domain, in winter and summer. Our own survey data showed Grampus can still be observed over slope waters in various regions. To explain the dramatic presence drop, one hypothesis would be that western Ligurian waters are now less suitable for Risso's dolphin feeding. However, the species diet is diverse, consisting in various species of benthic or pelagic squid. Another hypothesis would be that the sperm whale, also a squid-eater, takes a larger share of the prey biomass, which is possible since this species is now more frequent compared to 20-30 years ago.

Perinate bottlenose dolphin mortality following the Northern Gulf of Mexico unusual mortality event

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During the Deepwater Horizon oil spill Unusual Mortality Event (UME; 2010-2014) high numbers of perinate (premature, stillborn, neonate) dolphins were found dead along the northcentral Gulf of Mexico (nGOM) coast. Deaths were attributed to adrenal or lung disease in the dam, resulting in fetal distress with occasional in utero infections, including brucellosis. Unusually cold winters and increased freshwater discharge may also have contributed to the strandings. There has been no follow up assessment of perinatal stranding demographics since the close of the UME in 2014. This study defines perinate mortality trends on the nGOM coast from 2015-2019 for comparison to trends before (2004-2010) and during (2011-2014) the UME. Perinatal dolphins in this study stranded in Alabama, USA (where perinate mortalities were previously analyzed) during the peak calving season (Jan-May) and had straight length (SL) <115cm. Prior to the oil spill (2004-2010), there was an average of 3 perinate strandings per season (SL=101.4±3.6cm), with two (SL=110.5±4.5cm) in the season just prior to the spill. The first calving period following the oil spill (2011) perinate strandings increased to 26, most of which were late term aborted fetuses (SL=94.7±1.7cm). During 2012-2014, perinate strandings decreased to an average of 8 per season (SL=96.7±2.3cm), and following the UME (2015-2019) averaged 7 per season (SL=99.4±1.9cm). Necropsy and histologic examination on all fresh dead and moderately decomposed perinates from 2015-2019 showed fetal distress. There were occasional cases with in utero pneumonia (bacterial or parasitic infections), however, all lung tissue was PCR-negative for *Brucella*. These findings show high perinate mortalities continue along the nGOM coast, with late term abortions and signs of fetal distress. The underlying cause of these failed pregnancies remains unclear, but could include residual effects of the oil spill, infectious disease, or other environmental stressors negatively impacting the dams' health during pregnancy.

Variation in body condition in maternal female humpback whales over the course of the breeding season provides a useful tool for the comparative assessment of the quality of humpback whale nursery grounds

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In maternal female humpback whales, *Megaptera novaeangliae,* changes in body condition over the course of the breeding season potentially provides a useful tool for the comparative assessment of the quality of humpback whale nursery grounds. As capital breeders, maternal humpback whales utilize stored energy reserves to support the late stages of fetal development and the crucial early periods of lactation while effectively fasting. Consequently, energetic reserves are finite, conservation of available energy reserves is essential and high levels of disturbance during the earliest periods after parturition may impact both the immediate and future fitness of offspring. In this study, we used aerial photogrammetry, gathered using a small UAS to track changes in maternal body condition relative to the age of the calf. Limitations of the onboard altimetry included in the UAS were addressed by incorporating a calibration within each sample. Calves were classified as neonates and non-neonates based on several characteristics; the body length of the calf relative to the maternal female, color difference between calf and maternal female, and the presence of known neonatal features such as residual neck indentations. Body

length to surface area ratios of the maternal females were then compared to give body condition indexes at different stages of calf development. Initial analysis indicates a significant decline in body condition in maternal females between these two calf stages, from a mean body condition index of 1.56 (s.d. 1.5) for mothers with neonate calves to 1.43 (s.d. 0.7) for mothers with non-neonate calves ($p = 0.029$). As body condition details for the Hawaii Distinct Population Segment have yet to be compiled, these details provide an initial baseline that can be applied to track variations between seasons and, with further refinement of this protocol, potentially between different nursery regions that are used by maternal humpback whales.

Objective separation of body motion and orientation from accelerometer data

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Animal-borne accelerometers can provide information on the behavior of marine mammals underwater, like measures of energy expenditure, three-dimensional movement and prey-capture attempts. Accelerometers measure the total *g*-force in three axes, consisting of both a static and dynamic component. The dynamic component relates to the active acceleration or body movement, like swimming. The static component relates to the animal's body orientation. Changes in body orientation are generally more gradual than active acceleration, and can therefore be estimated by applying either a smoother or filter to the raw accelerometer measurements. However, which the choice of filter or smoothing method and defining the smoothing window width or cut-off frequency remains subjective.

We propose a methodology to separate the static and dynamic component more objectively. It is based on the vectorial sum of the three static dimensions being equal to the gravitational force of 1*g* (=9.81 ms^{-2}). Therefore, the size of the smoothing window or cut-off frequency leading to a static component which is closest to 1*g* should yield the best approximation of this static component. This is tested on simulated data and accelerometer data from five species, with a main focus on harbor seals (*Phoca vitulina*).

The simulated data demonstrate the capacity of the method to correctly select the optimal smoothing window and cut-off filter frequency. In actual accelerometer, the exact value of optimal smoothing or filtering varies between species and types of behaviors. This suggest that a single pre-defined smoothing window or cut-off frequency which is currently used may not always be appropriate. The proposed methodology could improve estimates for body orientation and motion, and hence, lead to a more precise description of how marine mammals behave.

Identifying the northwesternmost reproductive site of the endangered Mediterranean monk seal (Monachus monachus) in the Eastern Mediterranean Sea

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The Mediterranean monk seal is the most endangered pinniped species on Earth. After the most recent reevaluation of the species' status in 2015, the Mediterranean monk seal was listed by the IUCN as "Endangered" and population monitoring was identified as one of the most important research and conservation priorities. In 2017-2018, we carried out, for the first time, population-monitoring efforts in the Northern Ionian Islands in Greece, an area stretching from the island of Andipaxoi in the South to the islands of Othonoi and Ereikoussa in the North, including the adjacent coastlines of mainland Greece. Efforts included extensive surveys over 540 km of coastline in order to: a) evaluate habitat availability and suitability, b) confirm and evaluate habitat use by the seals and c) collect demographic data. Field data were collated with information on monk seal sightings collected through the National Monk Seal Rescue and Information Network. Our results indicate the presence of suitable habitat for the Mediterranean monk seal in the Northern Ionian Islands (i.e., 7 marine caves suitable for pupping and resting, 14 suitable only for resting); 11 seal sightings were recorded during the study, including that of a newborn pup. This finding indicates the presence of a reproductive monk seal group in the

area, which now represents the northwesternmost reproductive site of the species in the Eastern Mediterranean Sea. Considering the ongoing threats of habitat deterioration and increased human activity (mainly tourism-related) to the species in the area, in conjunction with the recent spate of extra-limital sightings of monk seals (and especially weaned pups) in neighboring Albania and Italy, we believe that effective conservation measures are urgently needed in order to: a) secure the fate of this newly-discovered monk seal pupping nucleus, and b) prepare the public for the reappearance of the species in the neighboring counties.

Features of diagnostics of diseases and causes of death of wild cetacea of the Black Sea.

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In 2017 at seaside of Krasnodar region, based on publications of the media, reports of the local people, as well as on our own observations, a rather high number of deceasedcetaceans was found with had skin lesions in the form of erosions. It became the prerequisites for organizing systematic work on accounting ofstranded cetaceans and determining the possible causes of death in 2018-2019.

When dead animals were found, the degree of preservation / freshness/ decomposition stage of the corpse was noted, among other things. In cases when freshness was reliably known, for example, when recording the time of death of an animal, biological material was taken for subsequent microbiological, toxicological, and genetic research.

While studying the skin lesions of deceasedanimals, we found no injuries recorded in 2018 in any individual. However, more than 20 cetaceans showed damage characteristic forby-catch in fishing gear. These are characteristic scars and drawings left by the nets, as well as cut off fins and flukes. When studying the presence and amount of toxicants in the body of this individuals, all the studied substances were found in insignificant amounts: organochlorine compounds, synthetic, organophosphate pesticides and dichlorodiphenyltrichloroethane and its metabolites.

As a result of microbiological studies of material from the fallen harbour porpoise, bacteria were found in the material from the upper respiratory tract *Streptococcus iniae*- hemolytic, significantly predominant in seeding and *Staphylococcus epidermidis*- pathogenicity factors which have not been established. In the material from the surface of the skin and from the oral cavity bacteria of the *Staphylococcus, Escherichia, Providencia* were isolated. The presence in the respiratory tract of a fallen animal of hemolytic streptococcus in significant amounts may indicate the presence of infectious pathologies of the respiratory tract, which could cause the death of the animal.

Humpback whale winter distribution and core habitats in relation to SST in offshore and coastal areas off the coast of Ecuador.

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Humpback whales migrate along the South American coast from feeding grounds off the Antarctic peninsula and Southern Chile to breeding areas off Peru, Ecuador, Colombia and Panama. In temperate and tropical regions, climate change, may cause shifts in cetacean distribution away from tropical waters towards higher latitudes; however, whether these shifts affect humpback whales in their wintering grounds, is unclear. With visual and acoustic surveys from the South to the North of Ecuador on board a sailboat in 2013 and 2014, we determined core habitat characteristics for humpback whales breeding off the coast of Ecuador in inshore and offshore waters. We analysed changes in distribution patterns in relation to El Niño Southern Oscillation (ENSO) events with Generalized Additive Models (GAMs) for the surveys and with long-term sighting data collected in a subtropical and a tropical breeding ground. Humpback whales were observed both in inshore and deep offshore waters with songs recorded as far as 100 km from the coast in depth of up to 2000m. They preferred shallow continental shelves off the coast with areas of relatively warm surface temperature (24-27°C) and within 10-20km from the coast. Sighting rates during years that had been preceded by ENSO conditions were significantly lower in subtropical breeding grounds than those in cooler years. Our data evidence that humpback whale distribution in their wintering grounds is influenced by local SSTs as well as region-wide phenomena (ENSO), and thus could indicate that in

the future their distribution may shift with warming ocean temperatures.

Inter-island variation in endocrine stress responses may be linked to anthropogenic pressures on the endangered Galapagos sea lion.
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Pinnipeds are frequently exposed to a multitude of anthropogenic stressors, including habitat encroachment, noise or chemical pollution, and fisheries interactions. These potential stressors may lead to elevated glucocorticoids (predominantly cortisol) in individuals, which when sustained, can ultimately disrupt normal physiological function or behavior by altering energy mobilization and use. The Galápagos Islands provide a natural experiment to assess the physiological impacts of sustained disturbances on an endangered species found throughout the archipelago, the endemic Galápagos sea lion (GSL). Several islands are uninhabited or restricted, but others consist of localized hotspots of tourist visitation, human habitation near sea lion colonies, and consequently, exposure to pathogens from domestic or introduced species. We collected serum and compared both basal cortisol (n = 121) and the induced cortisol stress response (ISR) mounted during capture (n = 42) in juvenile GSL among several colonies with vastly different degrees of human influence. We also quantified thyroid hormones T4 and T3, glucose, and testosterone to determine associations between cortisol responses and how metabolism and reproductive hormones may be altered in stressed populations. Controlling for sex and body size, we found that GSL in a highly disturbed colony on San Cristóbal Island had both significantly higher basal cortisol concentrations and lower ISR. Lower ISR was also associated with decreased concentrations of thyroid hormone T3 and glucose, suggesting that individuals with a reduced ability to mount a stress response to a short term challenge had downregulated metabolism. Furthermore, testosterone was high in socially dense colonies (based on individual abundance), which likely reflect a more stressful and competitive environment amongst conspecifics. These results indicate that several aspects of sea lion physiology are modulated in areas of high disturbance and, together with metrics of spatio-temporal and environmental variation, should be considered when making human-wildlife conflict management decisions.

Whales of the deep: Horizontal and vertical movements shed light on humpback whale use of critical pelagic habitats in the western South Pacific.
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Humpback whales (*Megaptera novaeangliae*) are known for their nearshore distribution during the breeding season, but their pelagic habitat use patterns remain mostly unexplored. In New Caledonia, an archipelago located in the western South Pacific, several offshore seamounts and banks are visited by humpback whales. Yet, the reasons why whales would aggregate and move between these offshore waters remain poorly known. From 2016 to 2018, 18 humpback whales were equipped with depth-recording satellite tags to shed light on environmental and social drivers of seamount association around New Caledonia. Shallow seamounts (< 500 m deep) spatially structured movement paths at small and large scale. Indeed, two males stopped over the Lord Howe seamount chain (3 to 7 days) during the first-ever recorded longitudinal transit between New Caledonia and the Australian East coast. Movement paths were modeled with Correlated Random Walks to estimate the position of dive events. Residence time was found to significantly increase with proximity to shallow seamounts, while dive depth increased within 100 km of these seabed features. Most of the 7,986 recorded dives occurred above 80 m (88.5%), but deep dives (> 80 m, max 616 m) were also regularly recorded (11.5%), including by maternal females. Deep dives often occurred in series and were characterized by U-shapes suggesting high-energy expenditure. Based on observed patterns of vertical and horizontal movements, we hypothesize that seamounts could 1) constitute navigational landmarks, 2) provide favorable conditions for opportunistic feeding, and 3) have acoustic properties facilitating male song propagation. At a broader scale, humpback whale use of seamounts is predicted from habitat models based on boat-based surveys conducted over the

entire Oceania breeding range. Given increasing anthropogenic threats to deep sea habitats worldwide, these new insights into the use of seamounts by humpback whales during the breeding season have both ecological and conservation

Outreach on the case of Arctic sealing: Opening up for a reframing of the sustainability discourse?

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Whales and seals continue to be major resources for Arctic communities and hunting them a part of long-standing cultural traditions. However, the question of whether whales and seals can be sustainably harvested as living marine resources is typically seen as a topic too controversial to discuss in the public sphere. In 1992, the Faroe Islands, Greenland, Iceland, and Norway established NAMMCO - an intergovernmental organization to foster cooperation on research, conservation and management of marine mammals in the region, and to provide management advice (based on scientific evidence and user knowledge) for both their *conservation and use*. In the current climate of international public opinion, this leaves the organization with a particularly unique challenge regarding outreach and education. How to communicate not only conservation concerns, but also the potential sustainable use of marine mammals as living resources in a global perspective? This talk will describe how NAMMCO is approaching this unique outreach challenge through an ecosystem perspective. It will present a pilot study using Life Cycle Assessment (LCA) showing that consuming seal meat in Greenland results in lower greenhouse gas emissions and other advantages than pork imported from Denmark. However, the European ban on seal trade has significantly reduced income sources for many Greenlanders, who can no longer afford to hunt and are now turning towards these cheap but less sustainable protein imports. Furthermore, the high pollution levels documented in certain marine mammals have led to the Governments of Greenland and the Faroe Islands advising that they not be eaten, at least by certain segments of the population. The presentation of this case illustrates how raising questions about what is sustainable and environmentally damaging from an ecosystem perspective can help reframe outreach efforts in a way that opens up for new conversations about conservation and use for Arctic resilience.

Acoustic identification of odontocete cetaceans in coastal waters of the Southwestern Atlantic Ocean

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This is a preliminary study to establish a library of odontocete whistles for a PAM in southeastern Brazil. Data were collected in two years in the northern coast of São Paulo state, specifically at the Canal de São Sebastião (CSS, 23°49' S; 45°24' W) and at the Anchieta Island (PEIA, 23°33' S; 45°04' W). A total of 30 detection events were recorded in the CSS and 137 in the PEIA. Seven acoustical variables were extracted from 5,644 whistles of detection events. The same acoustical parameters were extracted from whistles of *Orcinus orca* (*Oo*), *Tursiops truncates*, *Stenella frontalis* (*Sf*) and *Sotalia guianensis* (*Sg*) visually recorded through oceanographic cruises in the study area. PCA was used for analyses plotted with the averages of the acoustic parameters of the whistles of the four delphinids in relation to the whistles of each detection event, and simultaneously the prediction from the random Forest (RF) classification model. A total of 716 whistles and all the acoustical parameters extracted from the library identification were considered to train and validate the used model. The RF multivariate analysis presented 64% accuracy in species identification predictions. Based on mean decrease in accuracy, the most important variables for classification were duration, and the final, minimum, central and bandwidth frequencies. The RF analysis showed that *Oo* and *Sf* showed whistles with similar physical acoustic characteristics. The best species classification was *Sg*, with 91% accuracy predictions. The whistles identified in the detection events were incorporated into the RF model. The acoustic detector database was enriched in training data with 3,274 whistles of *Sg* and 12 whistles of *Sf*. The new RF model presented 89% accuracy in predictions, increased the accuracy for *Sg* identification to 98% and decreased it for *Sf*.

It is a match! evidence for whistle matching in common dolphins (Delphinus delphis) and Atlantic white-sided dolphins (Lagenorhynchus acutus)

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Whistle matching has been defined in bottlenose dolphins as an exchange of the same whistle type between two or more animals. Although fairly well studied in bottlenose dolphins, which are known to copy signature whistles of close associates, little is known about whistle matching in other delphinids. We found strong evidence of whistle matching in common dolphins (*Delphinus delphis),* and possible evidence in Atlantic white-sided dolphins (*Lagenorhynchus acutus*), from recordings made in Wellfleet, Massachusetts, USA. In total, 6,287 hours of acoustic recordings (from 2014-2017) were analyzed. Delphinid vocalizations were found in 124 hours of recordings, of which approximately 75% were *D. delphis* and 25% *L. acutus*. Species were confirmed using sighting data when available; otherwise call contour parameters were used. Using conservative criteria for copying, such that whistles of the same contour overlapped each other, we found 157 likely matches and 20 possible matches in *D. delphis*, and only ten likely and four possible matches in *L. acutus.* Even after normalizing for recording time, *D. delphis* produced approximately 10 times more matches than *L. acutus*. By using the SIGID method, we made conservative estimates of how many of these whistles were signature whistles. In *D. delphis,* there were 35 signature whistle matches involving 15 distinct signature whistles. In *L. acutus,* nine whistle matches were signature whistles, involving three signature whistle types. We also observed two instances of chorusing, defined as repeated and overlapping occurrences of the same contour, in *D. delphis*. These data provide some of the first insights into whistle production in two poorly studied delphinid species, and suggest that there may be key differences in their communication patterns. Concurrent behavioral observations are needed in order to understand how whistle matching and chorusing function in the natural communication systems of these two species.

"Fast and judicious": Foraging kinematics of South African Inshore Bryde's whales.

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South African inshore Bryde's whales (*Balaenoptera edeni*) face increased pressure from reduced prey availability and fishing gear entanglements, yet their foraging behaviors remain unknown. Investigating foraging kinematics is fundamental for assessing foraging energetics and for adopting efficient conservation efforts. To understand how they pursue and catch prey, we deployed 3D movement and camera tags on five Bryde's whales in Plettenberg Bay, South Africa, in April 2018. We identified 145 feeding lunges and 65 aborted lunges. Feeding lunges were divided into three phases: *acceleration,* which lasted 15.2 s (range: 2.1–81.8 s), *engulfment* (4.2 s, range: 0.7–22.1 s), and *filtration* (50.6 s, range: 32.7–54.1 s). Mean peak lunge speed was 5.2 m s^{-1} (range: 3.7–7.9 m s^{-1}) and mean minimum speed during filtration 2.5 m s^{-1} (range: 1.65–5.89 m s^{-1}). Foraging lunges occurred at an average depth of 50 m (range: 3–100 m). Individuals foraged at distinct depth strata and often spent a considerable amount of time searching for prey, the mean inter-lunge interval lasting 9.25 min (range: 0–75.4 min). Whales showed a strong right-sided rolling preference during acceleration (72% of feeding lunges) and highly acrobatic manoeuvres, primarily when feeding in waters <25 m (mean degrees rolled during lunge: 109°; range: 38–375°). This is the first fine-scale description of Bryde's whales lunge-feeding kinematics, showing that they lunge faster than other balaenopterids and often interrupt lunges before opening the mouth. Our results suggest that Bryde's whales have high energetic costs associated with foraging due to the relatively high speeds and acrobatic manoeuvres detected. These high-speed manoeuvres performed in shallow waters may explain the high rate of entanglements in coastal fishing gear. This study represents the first step towards understanding the energetics of foraging in Bryde's whales and will provide critical information for effective conservation management.

Brucella ceti and cetacean morbillivirus co-infection in striped dolphin from the Adriatic Coast of Molise region (Italy)

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Cetacean Morbillivirus (CeMV) and *Brucella ceti*, are two neurotropic concern of cetaceans. Both are often co-infected pathogens. We herein report *B. ceti* and CeMV co-infection in a striped dolphin (*Stenella coeruleoalba*) stranded on the Adriatic Coast of Molise region (Italy) in February 2019. Many organic tissues and body fluids for a range of laboratory investigations were collected during postmortem examination in this dolphin (preservation code 2). According to the technique described in the OIE Manual of Diagnostic Tests and Vaccines, *Brucella ceti* was isolated from uterine exudate, mammary gland, liver, spinal cord, medulla oblongata, bladder, spleen and finally from a lung warm. The strain was subjected to identification and characterization. A co-infection by *Cetacean Morbillivirus* was demonstrated from lung, spinal cord, bladder and spleen. The phylogenesis of the viral strain is underway. Histologically *B. ceti* and Cetacean Morbillivirus were associated with severe lesions of meningoencephalitis and ganglioneuritis. The two pathogens were also detected by immunohistochemistry and immunofluorescence. It is difficult to dissert the individual roles played by each pathogen on the development of the central nervous system (CNS) lesions affecting. Noteworthy we obtained direct evidence of *B. ceti* within individual lung worm, which most likely carried the pathogen to the lung parenchyma from which *B. ceti* could have started its subsequent colonization of the other body tissue district including the dolphin's central nervous system.

Assessing sperm whale (Physeter macrocephalus) occurrence, distribution and group size in Southern Tyrrhenian Sea through photo-identification.

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The sperm whale (Physeter macrocephalus) is one of the common species of the Mediterranean Sea however few studies have documented the occurrence and group characteristics of sperm whale in Southern Tyrrhenian Sea. The current study used photo-identification data collected by dedicated boat surveys between March-November from 2013-2018 to investigate occurrence, distribution and group characteristics (group size, sex and age class) of sperm whale in the Aeolian Archipelago (Southern Italy). Totally 42 sperm whales were sighted on 20 sightings and 24 individuals were photo-identified by mark types on tail and other body regions. The sex and age class was determined for 20 individuals(47,6%): 9,5%(n=4) were calves, 26,2% (n=11) immatures (10 males and 1 female) and 11,9% (n=5) adults (only females). A sperm whale was resighted in one case, on March 2013 and twice in 2014 (June and September). The mean (± St. Dev) group size was 2,1 ±2,01 ranging from 1 to 8 with the larger groups sighted in 2013 (6 individuals) and 2016 (8 individuals). The occurrence was higher in summer(n=9) and similar in spring (n=6) and in autumn (n=5) ranging from March to November months. The sperm whale encounters were classified as: (1) solitary individuals (60%); (2) social units (10%); (3) bachelor groups (0%) and (4) clusters (30%). The spatial distribution of sperm whale groups in the study area was assessed in the different seasons. These results the Aeolian Archipelago located in Southern Tyrrhenian Sea is an important stepping stone and potential breeding ground for Mediterranean sperm whales. Further results will be needed to estimate sperm whale distribution, abundance and behaviour in this area. Long-term photo-identification efforts and comparison of photo-id data from other Mediterranean areas is also needed.

Characterization of cetacean morbillivirus from striped dolphins (Stenella coeruleoalba) stranded along the Italian Adriatic coast , 2017-2019.

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Cetacean Morbillivirus (CeMV) is a RNA virus infecting marine mammals. Nowadays, CeMV is regarded as an emerging threat being the cause of recent epidemics worldwide. In 1990-92, a CeMV (dolphin morbillivirus-DMV strain) outbreak in the Mediterranean Sea involved thousands of striped dolphins (*Stenella coeruleoalba*) with high mortality. Another major epidemic event was the CeMV outbreak in 2006–08 affecting two cetacean species along the Mediterranean coast: the striped dolphin, and the long-finned pilot whale (*Globicephala melas*). In this work, we describe the identification and the genomic characterization of CeMV strains identified, during the Italian national monitoring activities, in cetaceans stranded along the Adriatic coastline of the Abruzzi, Molise and Apulia regions from 2017 to 2019. During this period, a total number of six carcasses of striped dolphins (preservation code from 2 to 3) were necropsied and samples from several tissues were collected. Nucleic acids were purified from all tissues and the presence of CeMV RNA was investigated by PCR-based assays targeting the P, H and N genes of CeMV. Nearly all tissues of all individuals tested positive for CeMV RNA and sequencing of amplicons revealed a nucleotide identity of 99.9-100% among the identified strains. Phylogenetic analysis performed on a portion of the N sequence showed that CeMV sequences obtained, cluster with DMV strains recently identified in Portugal and Galicia and separated from the Western Mediterranean and Canarian sequences, including the early CeMV isolates of 1990-92 and 2007-08 outbreaks. Isolation and NGS of the identified strains is currently underway. Overall, molecular characterization and phylogenetic analysis showed that CeMV (DMV) sequences detected in Abruzzi, Molise and Apulia regions in 2017-2019 clustered with those recently identified in Portugal, Galicia (Spain) and Italy representing a novel DMV strain of Atlantic origin which entered the Mediterranean Sea and affected a naïve striped dolphin population.

Yes, personality matters: Personality and social organization in wild bottlenose dolphins.
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Many social animals show clear preferences to associate with particular individuals to facilitate survival and fitness. Understanding the mechanisms that determine who associates with whom is a recent challenge for behavioural ecologists. Although animal personality has been demonstrated in multiple taxa, and affects many aspects of an individual's behaviour, life history and fitness, very little is known about the relationships between personality and social organization. Combining long-term behavioural data and social network analysis, this study describes personality differences between wild bottlenose dolphins and quantifies, for the first time in marine mammals, the influence of personality on social structure. Personality traits were assessed by repeatedly measuring the reaction of individuals of a social community to novel and threatening conditions as a trade-off between a risk-prone behaviour (boldness) and a risk-averse behaviour (shyness). Social structure was examined based on personality while controlling for age, sex, gregariousness, habitat use, and number of cumulative sightings using Multiple Regression Quadratic Assignment Procedures and Generalized Affiliation Indices. Findings of this study reveal a non-random mixing of individuals in a social network based on their personality traits. A relationship between tie strength, temporal stability, and network centrality and personality was observed, with bold individuals having a central role in the social network with denser and more stable associations than shy individuals. Results of this study also denote a homophily based on personality trait that may increase foraging efficiency through cooperative foraging and social learning. This study provides a novel insight on how a marine mammal can adapt via phenotypic plasticity to environmental changes and highlights the importance to advance the understanding of ecological, evolutionary, and conservation implications of animal personality.

Toxicological and management implications of toothed whales having higher exposure to contaminants than carnivore species
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Contaminant loads of persistent organic pollutants (POPs) and mercury (Hg) are known to be higher in Arctic toothed whales (e.g. killer whales (*Orcinus orca*), narwhals (*Monodon monoceros*), belugas (*Delphinapterus leucas*) and pilot whales (*Globicephalus melas*) compared to Arctic carnivores like polar bears (*Ursus maritimus*) and seals, e.g. ringed seals (*Pusa hispida*), harp seals (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*). These differences are linked to Carnivora species, including Ursidae and Pinnipedia, having higher capacity to metabolize or eliminate contaminants than cetacean species. An example from East Greenland shows that killer whales have median concentrations of ∑PCB, ∑OHC (organohalogenated compounds), ∑BFR (brominated flame retardants) and ∑DDT being 3.8, 22.6, 7.1 and 229 fold higher, respectively, than polar bears collected in the same area and period (2012-2014) despite evidence that polar bears were feeding at a higher trophic position. The differences in the adipose POP concentrations may be linked to the differences in the liver microsomal enzyme activity and hence the ability to metabolize and excrete POPs arising from the phylogenetic development of cetaceans from a herbivore ancestor. For Hg, cetaceans lack the ability to excrete this metal through hair as compared to Ursidae and Pinnipedia, which leaves them with a higher Hg burden. These differences suggest implications of larger potential toxicological threats to toothed whales species generally from POP and Hg exposure. Furthermore, the consumption of toothed whales in Greenland, the Faroe Island and Canada by indigenous communities results in a larger human contaminant exposure and associated toxicological threat relative to consuming other marine mammals. This problem is being excacerbated by an increase in hunted toothed whale species and numbers in Greenland in recent years. This information should be taken into consideration by local management authorities when issuing quotas on marine mammal species for the different hunting regions within the Arctic.

Movements of gray seal (Halichoerus grypus) pups in the New York Bight and Gulf of Maine

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The occurrence of Gray seals (*Halichoerus grypus*) in the northwest Atlantic has increased considerably in number and range during the last two decades. To understand the post weaning movement of gray seal pups required a partnership between the Atlantic Marine Conservation Society, National Marine Fisheries Service, Northeast Fisheries Science center, Marine mammals of Maine and Cummings School of Veterinary Medicine at Tufts University. This program will deploy satellite tags over two seasons (January through February) and focus on the post weaning movements of gray seal (*Halichoerus grypus*) pups. During the first year of the project eleven animals were tagged between January 26th to 29th, 2019. The eleven gray seal pups represented by six males and five females were tagged. Four of the animals were tagged with SPLASH tags (Time Depth Recorders) and seven with SPOT 6 (Position and Temperature Tags) which collect haul out behavior location and temperature. Three haul out sites in southern New England and Gulf of Maine were selected, Muskeget Island MA, Great Point Nantucket MA, and Seal Island ME. One animal moved as far south as Delaware Bay over 260 nautical miles from its tagging site, while another moved east off Nova Scotia. This talk will outline the project goals and progress, partners and direction for the second year of sampling.

SouSA: A nation-wide collaboration to improve the conservation of South Africa's Indian Ocean humpback dolphins (Sousa plumbea).

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The Indian Ocean humpback dolphin is South Africa's most endangered marine mammal (Plön et al., 2016). Main threats in the country include shark-nets, noise pollution, overfishing, boat interactions and coastal development. Further development of South Africa`s Ocean Economy will likely increase pressure on the species even further. In response to a lack of empirical data on the species population status and threats at a national level in South Africa, a nation-wide research collaboration, the SouSA Consortium, was established in 2016 between 18 partners from 15 different institutions. The aim of the consortium is to generate and share data on a large geographical scale that would not be achievable by individual research groups, with the aim of improving the conservation status of the species in South Africa. The first collaborative study investigated movement patterns of individual humpback dolphins between research areas using existing photographic data (2000-2016) and created a national identification catalogue (Vermeulen et al. 2017). Only 247 individuals were identified nationally, some of which moved substantially between study sites. Overall, data suggest a total population size likely under 500 split into two subpopulations. Further projects under the Consortium relate to spatial and temporal patterns in skin disease and scarring in the existing photographic databases and the development of nation-wide static acoustic monitoring to investigate animal presence and individual numbers and movements using signature whistles. The Consortium strongly believes that Indian Ocean humpback dolphins should be considered a flagship species of the Western Indian Ocean coastline (Plön et al., 2016). We encourage the use of the SouSA framework for the establishment of an African or a global Consortium, in which collaborative efforts can be made to better understand the global aspect of the species' conservation status and main threats.

In the trenches: Year-round acoustic presence of sperm whales (Physeter macrocephalus) and underwater sound levels in the Hellenic Trench, Greece.

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The sperm whales (*Physeter macrocephalus*) in the Mediterranean Sea make a small, genetically isolated and endangered population. About 250 individuals are estimated to inhabit the Greek Seas, concentrated along the Hellenic Trench in the eastern Ionian Sea. In contrast to other places in the world, both social groups and mature males occur sympatrically in these waters. However, information on the seasonal presence of this species in the eastern Mediterranean Sea is sparse. Primarily because observations are limited to visual cetacean surveys that are typically not conducted between November and March. In a first attempt to collect year-round baseline information on sperm whale occurrence patterns in Greek waters, two Passive Aquatic Listeners (PAL) were deployed for 19 months, at Pylos Station (36.8 N, 21.6º E) in the Hellenic Trench, and at Athos Station (40.0 N, 24.7º E) in the North Aegean Trough. Results revealed the year-round presence of sperm whales at Pylos Station with a higher number of detections observed during late spring and throughout the summer. No sperm whale vocalizations were detected at Athos Station. An ambient sound level analysis revealed higher winter and lower summer levels at both sites largely driven by local weather conditions. Results showed that marine life in the Hellenic Trench area was exposed to relatively high low frequency (< 1 kHz) sound levels. Ambient sound levels below 1 kHz are typically dominated by anthropogenic sources such as commercial vessel traffic. Ship strikes and noise disturbance constitute major threats for the small Mediterranean sperm whale population. The results of this study are useful for sperm whale conservation efforts in the region, most importantly in the light of the Greek Government's plans to open up offshore areas for fossil fuel exploration and extraction.

Building a dictionary of humpback whale song units as a tool for assessing stock interactions

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South America hosts two stocks of humpback whales (*Megaptera novaeangliae*), stock A occupying Southwest waters of the Atlantic, and stock G, located in the Southeast Pacific. After breeding in these locations in the austral winter and spring, both stocks travel in the austral summer to the feeding areas located in the Magellan Strait, Corcovado Gulf and Antarctic waters. As being physically accessible to one another, feeding areas are the only possible meeting point of two stocks.·Male humpback whales use complex vocal displays to communicate throughout the year. These are known as songs, subjected to constant evolution. Here, to assess changes in South American humpback whale song, we have analyzed units as its simplest elements Units were used to build the first ever unit dictionary of these stocks and compare their songs. Unit dictionary is a common method in studying bird song, while rarely used in humpback whales. To build the dictionaries, multiple years of songs from both stocks were recorded on their breeding grounds, feeding grounds and during migration, by various researchers. Using units as the basis highly enlarged the amount of useable data from this diverse dataset. Additional adventage of this methodology is its simplicity, while likely potent to help uncover stock dynamics and interactions. Comparing dictionaries of these two stocks revealed high level of difference in song complexity, specifically stock G song units appear much more diverse. Further, stability in the number of different units varied between stocks, as stock A had a more stable number of different units used over the seasons. These findings highlight the importance of feeding grounds for cultural exchange and stock interactions, possibly upholding the dynamics of humpback whale culture altogether. Used dataset is the outcome of the largest collaboration effort in humpback whale acoustics in South America to date.

Population genomics of the Atlantic spotted dolphins (Stenella frontalis) across the Atlantic Ocean.

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The Atlantic spotted dolphin (*Stenella frontalis*) is endemic to the tropical and subtropical Atlantic Ocean. The most comprehensive analysis conducted so far based on the mtDNA control region marker identified different populations in the Eastern North Atlantic (ENA), Western North Atlantic, Gulf of Mexico, and Western South Atlantic (WSA). In order to better investigate the relationships between some of these populations, we used Double Digest restriction-site-associated DNA sequencing method to obtain genome-wide Single nucleotide polymorphisms (SNPs). We successfully genotyped 73 individuals representing the following geographical regions: ENA (Canary Islands, n= 7), Caribbean (Colombia, n=5; Guadeloupe Island, n=1), WSA (Brazil, n= 61; Uruguay, n=1). Three different datasets with different number of SNPs (ranging from 9,450 to 83,512 SNPs) were used to test the patterns of genetic differentiation and to evaluate specifically the genetic distinctiveness of WSA population. Our clustering results and population differentiation analyses suggests there are at least three regional groups (Southeastern Brazil, Colombian Caribbean, and an oceanic group). Our findings revealed that genetic similarity is primarily correlated with geography and, to a lesser extent, environmental conditions. Indeed, we detected a fine-scale population structure among Southeastern Brazilian individuals. This substructure is comprised of a group that inhabits the inner and midshelf (10 – 80 km from the coast) of the Southeast Brazilian Bight (SBB), and another group that occupies the outer shelf (80 – 120 from the coast). Dolphins of this latter group have a similar genetic makeup to individuals from geographically distant locations, including the Canary Islands and Colombian Caribbean individuals. Furthermore, individuals associated with inner and midshelf waters have a restricted geographic distribution that is suggestive of a demographically distinct population. These findings are meaningful and should be considered in management and conservation decisions, especially in the Southeastern Brazil, where anthropogenic pressure faced by marine organisms is increasing.

What if fishermen are doing their homework? Implications of communication gaps in cetacean bycatch knowledge. The case of longliners in Cape Verde.

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Bycatch is generally seen as one of the most important threats for marine mammals, so better data is needed to understand the impact it has on their populations. Collection of bycatch data has been a demand to fisheries operators from the scientific and environmental sectors, in order to further investigate the interactions between the fisheries industry and cetaceans. But what if the data needed is already being collected?

Here we analyse the case of ORPAGU, a Spanish long-line operator targeting for swordfish and blue shark in Cape Verde. ORPAGU has been voluntarily collecting data for accidental catches of non-targeted marine megafauna, including marine mammals, turtles and birds. They do register as well cetacean sightings from their vessels. An enormous amount of information that, once collected, doesn´t get used due to communication gaps between institutions. During our research on the governance structure for fisheries in the area, we found that, as no governmental institution (from Flag State, Coastal State or EU) includes on its protocol the requirement for this data to be submitted, it doesn´t get analysed or made publicly available for other institutions (i.e. scientific institutions) to use. This leads not only to data being underused, but to fishermen feeling their efforts have no recognition and making them less keen to participate in any future conservation study. This case illustrates the fact that existing communication gaps between sectors, along with governance, should be thoroughly studied and identified when analysing accessible bycatch information for a specific area.

As part of the H2020 project Farfish, we use data collected by ORPAGU to present research examples on how this data could be statistically analysed and what information could be obtained from it, including species encountered.

Assessing summer body condition of humpback and blue whales using an Unmanned Aerial System (UAS) in Skjálfandi Bay, Northern Iceland

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Numerous and varied anthropogenic activities have the potential to disturb cetacean populations, mediated by behavioural and physiological responses. However, predicting the fitness consequences of such disturbance, requires

knowledge of baseline body condition and its variation within a population. Moreover, measuring fluctuations over time allows potential monitoring of the impact of stressors on animal health and fitness. Historically, tissue samples, beached cetacean carcasses, and active whaling have been used to study body condition as a proxy of whale health. Recently, more modern techniques like unmanned aerial system (UAS, *i.e.*, drones) are being to be used to assess body condition, representing an affordable and unobtrusive method. These studies have largely been conducted in breeding grounds where waters are clear. However, monitoring body condition in feeding grounds is essential to elucidate patterns in energy acquisition, which may in turn determine the impact of anthropogenic stressors. In this study, UAS imaging will be used to monitor body condition of humpback (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*) in Skjálfandi Bay, northern Iceland, an important summer feeding ground. A DJI Phantom 4 UAS will be deployed from a five-metre research vessel in order to capture aerial images of single animals. Measurements of length and widths at 5% increments followed by calculations of relative whale surface area (pixels^2) will be completed using R. Following this, absolute values will be calculated using the height of the UAS above the animal, determined with an inbuilt pressure sensor. Errors in UAS altitude, measurement accuracy and image clarity will be calculated using covariance and bootstrap resampling methods. This will allow assessment of the feasibility of this method to accurately measure body condition in cetaceans in a northern feeding ground. This method will be applied to real-time measurement of energy acquisition during the feeding season and its variation within a population.

How wrong and how useful? Using a fully censused population of killer whales to test the robustness of population models.

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Population models are useful tools to estimate life-history parameters and abundance trends, to make predictions and to test management scenarios. However, the survey and demographic data informing these models are often characterized by considerable uncertainty (e.g., incomplete time series, abundance estimates with large errors) and therefore numerous assumptions must be made. For instance, it is frequently assumed that individual members of a population are identical and can be lumped together (e.g., surplus production models). Models including sex and age-structure are more realistic but the required individual-level information is not always available. Therefore, we examined what can be learned from data-rich situations to inform data-poor systems. The population of northern resident killer whales is censused every year in Canadian Pacific waters, and information is available on sex, age and reproductive status of nearly all individuals. We used this dataset to test the robustness of several models that use varying degrees of information on population structure. First, we compared the ability of these models to reproduce the known "truth" in terms of numbers, trends and composition. Second, we tested their sensitivity to artificially deteriorated data (increasing uncertainty of abundance estimates and increasing intervals between surveys). Finally, we investigated common assumptions of density dependence mechanisms, the ability of models to estimate carrying capacity and the inter-annual variability in vital rates. Our results show that even simple models can adequately reproduce the observed population trends of a natural system, but struggle to explain fine-scale variations and predict future trends. Vital rates are shown to be more variable than usually assumed for cetaceans and highlight the trade-off between precision and frequency when allocating survey efforts. Our results also confirm the difficulty for any model to simultaneously estimate carrying capacity, growth rates and the shape of density-dependence relationships.

First detection of microplastics in wild northern fur seals, Callorhinus ursinus, throughout their eastern Pacific range.

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Microplastic pollution is increasingly reported in marine mammals and bioaccumulation may present

risks to animals feeding at higher trophic levels. Documentation of plastics in marine mammals often results from examination of stranded, sick, or captive animals that may not be representative of healthier, free-ranging individuals. Further, examination of animals routinely consumed by humans is lacking. We investigated microplastic pollution in wild northern fur seals (*Callorhinus ursinus*), a species subject to subsistence harvest in Alaska. We examined 44 feces from three sites encompassing the seal's eastern Pacific range: St. Paul and Bogoslof Islands, Alaska and San Miguel Island, California. Physical sieving of individual feces to 250µm was followed by wet peroxide oxidation to digest organics and density separation of remaining material using a 5M sodium chloride solution. The resulting suspended low density material was re-sieved, dried, and visually inspected at 40X magnification. Polymer composition of select microplastics recovered was determined using Fourier-transform infrared spectroscopy (FTIR). Extensive field and laboratory contamination control measures were implemented inclusive of procedural blanks, ambient air controls, and substrate samples, among others. A total of 398 microplastic fragments and 186 microplastic fibers were recovered from the 44 feces. Fifty-five percent of feces (24/44), but no controls, contained fragments (range 1 to 86 fragments/feces, mean 16.6, sd 19.1). Most (82%) fragments were <1mm in size. There was no difference in the probability of presence of fragments in feces by location ($p = 0.28$). Fragments tested using FTIR were low density polyethylene. While fibers were recovered in feces, they were also found in controls indicating likely contamination, highlighting the pervasiveness of synthetic fibers, and precluding conclusions regarding fiber origin. Fecal analysis documented the widespread presence of microplastic fragments in wild northern fur seals, a pinniped of cultural and conservation importance, throughout their eastern Pacific range.

Unexpected dietary shifts resulting from fishing intensification in marine mammals with gape-limited mouth.

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Aquatic predators are usually gape-limited and cannot fully exploit prey populations when dominated by the larger size classes. In small-gape marine mammals, the morphology of their rostral region largely determines their feeding mode and the maximum size of their prey. However, fishing may increase the availability of resources for small-gape marine mammals by reducing the average size of prey, even if total fish biomass decreases.

Here, we analyse changes throughout time in the isotopic niche of three sympatric marine mammal species –Franciscana dolphin (*Pontoporia blainvillei*), South American fur seal (*Arctocephalus australis*) and South American sea lion (*Otaria flavescens*)– from the Río de la Plata estuary to test the hypothesis that fishing modify the diet of small-gape predators by reducing the average size of prey.

We found that the three species differ largely in mouth gape being the palate breadth of Franciscana dolphins intermediate between those of sea lions (the broadest palate breadth) and fur seals (the narrowest palate breadth). Furthermore, we observed that Franciscana dolphins have undergone a dramatic dietary change since the 1970s and currently forage at the same trophic level than sea lions despite major differences in mouth gape. Conversely, there has been little change in the isotopic niche of sea lions and fur seals. At the same time, fishing modified the size class distribution of some demersal fish species, which likely improved accessibility to Franciscana dolphins. Change in the trophic level of Franciscana dolphins has resulted in a major change of the topology of the three species in the isospace. In the 1950s, Franciscana dolphins and fur seals overlapped largely, but currently the three species have different isotopic niches.

In conclusion, the impact of fishing on marine mammals goes beyond the simple reduction in prey biomass and the response is species-specific and largely mediated by mouth gape.

Using RNA/DNA ratios and carbon/nitrogen stable isotopes to assess the nutritional condition and trophic ecology of two cetacean species in an oceanic habitat.

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Environmental variability can have detrimental effects on individuals' physiology. In this study, the RNA/DNA ratios (RDs) were used for the first time to assess the nutritional condition of two abundant marine top predators, the common bottlenose dolphin *Tursiops truncatus* and the short-finned pilot whale *Globicephala macrorhynchus* in Madeira Island (Portugal). In addition, carbon ($\delta^{13}C$: $^{13}C/^{12}C$) and nitrogen ($\delta^{15}N$: $^{15}N/^{14}N$) stable isotopes (SI) were determined in order to obtain information on cetaceans' trophic ecology and habitat residency. To accomplish these aims, between 2017 and 2018, cetaceans' skin samples were collected from free-ranging animals along with muscle tissue samples from their potential prey. RDs showed that both species are in good nutritional condition, with higher values (ANOVA, $P<0.05$) being recorded in bottlenose dolphins. In fact, SI ratios differed between the cetacean species (PERMANOVA, $P<0.05$), with bottlenose dolphins presenting lower average (±SD) $\delta^{13}C$ (-18.6±0.4‰) and $\delta^{15}N$ values (10.2±0.7‰) than pilot whales ($\delta^{13}C$: -17.3±0.5‰; $\delta^{15}N$: 12.5±0.6‰). These, together with the stable isotope mixing model results (95%CI), suggest they assimilated different prey or different proportions of the same prey, and that bottlenose dolphins present a more diversified/opportunistic feeding behaviour. RDs and SI were similar between sexes, and only small differences were observed between seasons, which could be due to having sampled animals with different residency patterns in different seasons. Higher RDs (ANOVA, $P<0.05$) were recorded in visitor pilot whales, and visitor and transient whales presented higher ranges (PERMANOVA, $P>0.05$) in both $\delta^{13}C$ and $\delta^{15}N$ than resident whales, which suggests different feeding strategies or habitats in animals with distinct residency status. It is shown that the integration of nucleic acid derived indices and isotopic analysis provide a robust approach to infer the ecophysiology and food web dynamics of marine mammals.

Clinico-pathological findings in juvenile fur seals (Arctocephalus australis and A. tropicalis) stranded in São Paulo, Brazil, 2018: Preliminary results.

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Four Otariidae species have been reported as occasional or frequent vagrants along the coast of Brazil. There is limited available information on health and disease aspects of stranded fur seals in Brazil yet admission of debilitated animals is common mainly during austral winter in southern regions. Increased stranding rates were recorded during the winter season in southeast Brazil (Iguape [IG], Ilha Comprida [IC] and Ilha do Cardoso-Sao Paulo state) during 2018 (n=23 *vs* n=2 in 2017). This study aimed at reporting the clinico-pathologic findings including antemortem laboratory diagnostic analyzes and most likely causes of stranding and/or death (CSD) in five juvenile South American fur seals (*Arctocephalus australis*) and one juvenile Subantartic fur seal (*A. tropicalis*) admitted for rehabilitation and/or stranded dead in IG and IC, in 2018. Four animals stranded alive and two stranded dead. All animals were male and all but one had poor body condition. The main hematological conditions on admission were: dehydration (n=3); normocytic normochromic anemia (n=2); leukocytosis with neutrophilia and lymphocytopenia (n=2); and hypoproteinemia (n=1). Gross and microscopic pathologic examinations revealed a variety of lesions, predominating hemodynamic disturbances, endoparasitism and inflammatory processes of suspected infectious nature. One animal was

serologically positive for *Leptospira interrogans*. One animal was PCR-positive for *Sarcocystis* sp. and two were PCR-positive for *Neospora* sp. All animals were negative for canine distemper virus, *Brucella* spp., and *Toxoplasma gondii* on serological and molecular analyses. The most likely CSD were: starvation (n=3); aspiration pneumonia (n=1); asphyxia (n=1); and presumed systemic infectious disease (n=1). These findings add to the current knowledge on these two species and may be valuable to first responders, clinicians and diagnosticians.

A celebration of 25 years of marine mammal research on the west coast of Scotland

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The Hebridean Whale and Dolphin Trust (HWDT) is a marine conservation charity that has been leading the way for the conservation of cetaceans on the west coast of Scotland through robust long-term monitoring programmes for the last 25 years. Through our community sightings network, HWDT has collated over 28,000 sightings records from 3,284 individual contributors. The launch of the Whale Track smartphone application and website in 2017 capitalised on technological advances in citizen science, providing a quick and convenient way for users to report sightings, doubling the rate of reports. Our research vessel, *Silurian*, has been monitoring cetaceans through dedicated visual and acoustic surveys using standard line transect methodology (Buckland at al., 2001), as well as photo-identification techniques, since 2003, generating one of the largest databases of its kind in UK waters. *Silurian* has travelled 112,707 kilometres, recording 33,514 animals during 14,337 sightings of 16 different species and collected over 6,000 hours of underwater recordings. Since January 2019, dedicated surveys have been conducted during the winter months, providing crucial year-round monitoring for the first time in our history. Our research has critically advanced the understanding of resident and migratory species in Hebridean seas, and has established the west coast of Scotland as one of the most important areas for harbour porpoise (*Phoceona phocoena*) in Europe (Embling et al., 2010; Booth et al., 2013). It has helped identify important areas contributing to the identification of Marine Protected Areas (MPAs) for harbour porpoises, minke whales and basking sharks and is being used to detect trends and changes in the marine environment, such as the increase in underwater noise pollution (Findlay et al. 2018) and monitoring emerging threats like entanglement. Long-term monitoring of this nature remains our priority, ensuring we can continue to provide the evidence needed to inform effective conservation measures.

Species distribution modelling of fin whales (Balaenoptera physalus) in the North Atlantic section of the Arctic Ocean

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Understanding the dynamics of cetacean distribution in ecologically vulnerable regions is essential to interpret the impact of environmental changes on species ecology and ecosystem functioning. Species distribution models (SDMs) are helpful tools that link species occurrences to environmental variables in order to predict a species' potential distribution. Studies on baleen whale distribution in polar regions are comparably rare, mainly due to financial and logistic constraints. Here we use SDMs to predict habitat suitability for fin whales (*Balaenoptera physalus*) in Arctic waters.

A combination of opportunistic and systematically collected visual observations from 2007 to 2018 was used. Opportunistic data were collected during ten RV Polarstern cruises in the Arctic Ocean (including the Barents-, Norwegian and Greenland Sea). Complementary visual data were obtained from open source databases. Environmental variables were chosen based on ecological relevance to the species, comprising both static and dynamic variables. We used MaxEnt software to model the distribution of fin whales, using presence-only data as a function of carefully chosen environmental covariates. MaxEnt's predictive performance has been shown to be consistently competitive with the highest performing methods.

We were able to reveal important factors affecting the distribution of fin whales in the Arctic Ocean and how they respond to them. Results demonstrate the effective use of SDMs to predict species distributions in highly remote areas, constituting a cost-effective method for targeting future surveys and prioritizing the limited conservation resources. Results can be applied in a variety of purposes,

such as designing marine protected areas and support the further use of opportunistic data to understand the ecological drivers of species distribution.

Citizenry, science, and conservation: Power of the people.

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Citizen science networks add to the knowledge of presence and distribution of many cetacean species. They can coordinate, compile and accurately log data over wide spaces and long time scales, adding significantly to the body of data on whale and dolphin species. This can add directly to, or complement, more formal scientific endeavors.

More recently we have seen the involvement of interested citizens to promote specific areas of research, conservation efforts of specific species, and create political pressure for greater protection. From what was originally engagement in research, the broader public now creates pressure points that directs research funding for better science and conservation programs.

We have engaged in several types of interactions with citizen groups, such as sighting networks, intern programmes, and public media. By drawing on those cases we present examples of the positive effects, as well as some of the pitfalls that may be encountered. We also examine how interested citizens have, through their purchasing and footfall, media messages and social 'trending', have created platforms for change. Public engagement encourages an interest of marine research to a wide audience, and plays an expanding role in research.

Underwater noise levels around the Port of Saint John

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The Bay of Fundy is an environment rich in its biological diversity and highly productive ecosystems. The area is a hot spot for several species of whales, dolphins, seals, porpoise and shorebirds. Shipping contribution to ambient noise levels have increased as much as 12 dB over the past decades. With increased shipping in the Bay of Fundy and resulting increased noise levels from vessel traffic it is important to monitor underwater noise especially in areas frequented by at-risk species such as the North Atlantic Right Whale (Eubalaena glacialis). Noise monitoring can provide a baseline sound profile and data on how an area changes acoustically over time. For these reasons, an underwater noise monitoring project was created to monitor noise levels in the Bay of Fundy, around the Port of Saint John. Port of Saint John is Canada's third busiest port (by tonnage) and the fourth busiest cruise destination. Industry is important to the area as many livelihoods rely on the traffic in and out of the bay and port. For this reason, the underwater soundscape was studied focusing on vessel traffic as it entered port. Acoustic data was collected by hydrophones at multiple sites deployed outside the harbour over three years (2015-2017) creating a long-term acoustic profile of the area. Ambient noise measurements of the areas were compared over time. Emphasis was placed on 1/3-octave bands 63 & 125 Hz, associated with shipping activity by the Marine Strategy Framework Directive. Results will be interpreted to provide information on the baseline ambient noise measurements and noise pollution levels around the port. Results include detected marine mammals and vessel noise measurements. Results provide data not only for researchers, but for regulators, as well as baseline noise measurements for future environmental assessments of the area.

Descriptive epidemiology and pathology of the 2018 leptospirosis epidemic in California sea lions (Zalophus californianus).

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Leptospirosis, caused by *Leptospira interrogans* serovar Pomona, is endemic in free-ranging California sea lions (*Zalophus californianus;* CSL) with seasonal disease

outbreaks and periodic epidemics of high morbidity and mortality. Beginning July 2017, there was a marked increase in CSL admissions at The Marine Mammal Center with clinical signs of renal insufficiency including azotemia, hyperphosphatemia, hypokalemia, and hypernatremia. Based on standard age class criteria for this species, the greatest prevalence of infection was observed respectively among juveniles, followed by sub-adults, yearlings and then adults. The epidemic curve for juveniles peaked in August 2018 while that for sub-adults peaked in October 2018. Of 356 cases admitted July 2017 through December 2018, 92% were male and 56% were juvenile. Survival of juveniles was higher compared to other age classes (P<0.001). There was no effect of sex. Fewer yearlings and adults in the study precluded a determination of age-specific disease characteristics, so, an age class-specific pathology comparison was based on two age groups: (1) combined yearlings and juveniles and (2) combined sub-adults and adults. The first had significantly (X^2 8.225, p=0.0041) higher survival post admission than the second. At necropsy, lesions ranged in severity from nephritis with malnutrition and dehydration to an advanced uremic syndrome (nephritis, buccal and gastric ulceration, pulmonary edema, dermatitis and occasionally, cerebral edema). The full range of lesion severity was observed in young animals (group 1). However, for older CSLs, significantly more presented with the advanced uremic syndrome ($X^2$5.451, p= 0.0196). Further characterization of the immune response to infection is underway to investigate whether this could account for this disparity in pathologic presentation.

Satellite-linked telemetry study of a rehabilitated and released Atlantic spotted dolphin in The Bahamas provides insights into broader ranging patterns and conservation needs

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Despite dedicated longitudinal studies, lack of information on ranging patterns of "resident" dolphins can limit our ability to apply conservation directives at the appropriate scale. Here, we present satellite-linked-telemetry data on movements over 108 days (1,067 Argos locations) for an adult male Atlantic spotted dolphin (*Stenella frontalis*) in The Bahamas. On August 26th, 2018, this dolphin live-stranded in the Berry Islands, approximately 110 km east of Bimini, where photo-identification studies began in 1997. This individual (called "Lamda") was known to researchers in the Bimini area since 2013 where he was seen nine days prior to stranding. Lamda was transported to Dolphin Cay at Atlantis in Nassau on August 30th where he was diagnosed with pneumonia, gastric ulceration, gastritis, myopathy and dehydration and treated with vitamins, antibiotics and swimming physiotherapy. On October 29th Lamda was airlifted to the Bimini area, instrumented with a SPOT6 Finmount location-only satellite-linked tag and released. He moved south rapidly, covering 410 km in 48 hours, ending up near Cuba, well beyond what was previously considered his normal range. Lamda stayed in this southern area (3,572 km^2) for 13 days but there were no opportunities to document behaviors or potential associations with other dolphins. Over the next 16 days, Lamda returned to Bimini, and on January 7th, 2019, was observed in a group with other known Atlantic spotted dolphins. He remained in the Bimini area (1,203 km^2) until his tag stopped transmitting on February 14th. Assuming Lamda's movements are representative of ranging patterns by non-rehabilitated dolphins, these data provide insights that have important implications for conservation of this species. Notably, the majority of Lamda's locations were in the Bimini area where there is pressure from increasing tourism, and his locations in the southern area overlap with existing petroleum licenses where test drilling is scheduled in 2019.

Occurrence and photo identification of harbour porpoises in North Pembrokeshire, Wales.

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Photo-ID methods have been used to study cetacean populations since the late 1970's. Despite its success in other species, photo-ID is not commonly used to study harbour porpoises. This is most likely due to the challenges of photographing small, typically boat shy cetaceans who exhibit subtle surfacing behaviours and their lack of

obvious unique markings. Harbour porpoise populations are often studied at larger-scales, studies on smaller scales are often in relation to specific variables such as areas of high tidal energy. The species is seldom studied at individual or local levels. This has resulted in loose estimates of population size and dynamics and a lack of species protection in regards to the designation of Special Areas of Conservation.

Recently harbour porpoise photo-ID studies have developed and have large potential for success. The Pembrokeshire coast is an area of high harbour porpoise sightings. This high abundance and activity has allowed for the photography of individuals from land-based vantage points. This study photographs individual animals from four sites around North Pembrokeshire. Photos have been collated and organised into an identification catalogue. The catalogue currently contains 101 individually marked porpoises. New individuals per month range from 0-9, with on average 2.8 individuals identified each month. Sightings of individuals range from 1-18, with an average of 2.1 sightings per individual. 30% of individuals have been sighted on more than one occasion suggesting patterns of site fidelity or residency.

This study describes the early process and the preliminary results of an on-going photo-ID study on harbour porpoises. Already the study highlights the complexity of local occurrence and movement, something not identified with larger scale studies and has shown the potential that photo-ID studies can have when contributing to the overall conservation of the species, emphasising the need to continue this form of study.

A quantitative approach for analyzing surface interval behaviors of baleen whales in drone video

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Foraging in baleen whales is energetically intensive and requires a surface interval resting period between each foraging dive. Whales take advantage of such events to replenish oxygen stores and conserve energy. Here we provide a methodological approach for annotating unoccupied aircraft system (UAS)-based aerial imagery to encode and analyze exhibited surface behaviors. Using a Freefly ALTA 6 UAS, video data were collected synoptically with photogrammetric still imagery in Monterey Bay, California during August 2017. During these flights, foraging and surface interval events of blue whales (Balaenoptera musculus) were recorded along the perimeter of the Monterey Bay Submarine Canyon system. This initial study evaluates a subset of 5 flights containing behavior of 6 blue whales, having a mean surface interval of 1 minute and 14 seconds. Using the Behavioral Observation Research Interactive Software (BORIS) suite, we developed an ethogram and encoded surface interval behaviors for each individual exhibiting a solo swim event. Six primary behaviors were identified and designated as either a point- or state-event to address questions related to event frequency and duration. We then employed a discrete-time Markov model, using the coded behaviors, to identity conditional probabilities of each behavior's occurrence, conditioned on prior behaviors. We find that exhalation events remain 100% probable after primary surfacing events, and shallow dive and deep dive events also occur with high probabilities (60%-70%) after propulsion activities, such as fluking and pectoral strokes. In summary, this study demonstrates a quantitative approach to identifying parameters governing blue whale surface behavior, an approach that can be extended to other marine mammals. We find that BORIS is an effective tool for generating species-specific ethograms when used alongside embedded imagery to encode and analyze observed surface behaviors in UAS video data.

Population recovery of Arctocephalus philippii in the Juan Fernández Archipelago, southeastern Pacific.

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The Juan Fernández fur seal inhabits the Juan Fernández Archipelago (33º43'S; 79º52'W) and the

Desventuradas Islands (26º19'S; 80º00'W). Due to intense hunting during the 19th century by British and American sealers the population was nearly lead to extinction. In 1964 a few fur seals were registered by local fishermen, while Aguayo & Maturana (1969) censused 170-192 in Robinson Crusoe Island and 300 individuals were counted in 1975 in San Ambrosio Island (Desventuradas). In 2015, UICN moved the species from the category of 'Near Threatened' to 'Least Concern'. The colonies are located within the Archipielago de Juan Fernández National Park. In this context the Corporación Nacional Forestal (CONAF) has implemented a monitoring program for the species in the park since 2001. The surveys were performed during the austral summer using small boats to get to the colonies. The estimated population abundance was about 30,000 individuals in 2001, with sustained growth reaching 50,000 in 2007; 134,000 in 2012 and 220,000 in 2018. In the 2018 survey 24 colonies (19 rookeries) were registered in Robinson Crusoe Island and 7 (6 rookeries) in Santa Clara Island. 25% of the population were pups In Robinson Crusoe and 10% in Santa Clara. The population of Juan Fernández fur seals is recovering rapidly and the species is listed as Least Concern by UICN. Nevertheless, little is known about the population status in the Desventuradas Islands, therefore a survey of these islands is urgently needed. It is important to highlight that the Juan Fernández fur seal, *Arctocephalus philippii* is the most abundant sea lion population in the southeastern Pacific.

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Accounting for localization errors in models of behavioural responses of minke whales to sonar activity during Navy training

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Sound is an important sensory input for many marine mammals, and the introduction of anthropogenic noise into the marine environment may affect the behaviour of these animals. We assessed behavioural responses of minke whales to mid-frequency active sonar by comparing whale tracks during periods of Navy training with tracks during baseline periods. In particular, we have assessed how measurement errors in the localization process can affect these inferences.

Whale tracks are derived from passive acoustic monitoring on the Pacific Missile Range Facility, Kauai, Hawaii. Localizations obtained from acoustic detections are subject to measurement error that increases with distance from the hydrophone array. These errors are estimated by time-of-arrival information and knowledge of hydrophone geometry. We assessed the influence that localization errors have on behavioural inferences by comparing three models that account for error in different ways. First, we fitted a hidden Markov model to tracks that have been smoothed to remove measurement error, a process widely used in telemetry analyses. Second, we fitted a two-stage model that uses a continuous-time movement model to simulate tracks that are regular in time and compatible with the established range of localization error; each of these is then passed to a hidden Markov model for subsequent analysis, with inferences combined over tracks. Finally, we fitted a recently proposed multistate formulation of the continuous-time correlated random walk that allows the two stages above to be combined.

Results indicate that, while outputs from the three approaches differ, there is evidence of faster, more directed movement during sonar exposures than in the baseline period. Smoothing over localization errors tends to artificially inflate the significance of results, while larger localization errors can pose a problem for two-stage approaches. Correctly estimating and accounting for localization error in subsequent analysis of tracks is key to drawing justifiable inferences about behavioural responses.

Characterizing the seasonal and geographic distribution of North Atlantic right whales (Eubalaena glacialis) using an expansive spatial network of passive acoustic moorings

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Seasonal distribution of North Atlantic right whales (NARW) north of 45°N latitude is mostly unknown due to a lack of systematic monitoring along most of the eastern Canadian continental shelf. In 2017, an unprecedented NARW mortality event occurred in the Gulf of St. Lawrence (GSL, ~48°N) involving 12 documented deaths, several of which were due to ship strikes and fishing gear entanglements. The GSL was a previously unidentified habitat for the whales, and this event demonstrates the importance of identifying the contemporary spatio-temporal extent of this species' distribution. The objectives of this study are to 1) describe seasonal distribution patterns of NARW in Canadian waters; 2) identify areas of NARW presence outside of monitored aggregation areas, and 3) demonstrate the advantages of using passive acoustic monitoring (PAM) technologies to provide information on the presence of NARWs. To achieve this, we analyzed PAM data collected by 73 moorings and 14 gliders (~20,800 recording days) deployed across the Atlantic Canadian continental Shelf between 42°N and 58°N during 2015 through 2017. Daily NARW acoustic presence was assessed using manual validation of auto-detected upcalls with a low frequency whale detection and classification system. Generalized linear models will be used to analyze seasonal and regional variation of NARW acoustic presence. Results from the first 34 analyzed deployments demonstrate the dynamic and widely varying geographic presence of NARWs. The period that NARW were present in Canadian waters generally decreased from south to north. For example, NARWs are present on the Scotian Shelf (45°N) nearly year-round (95th percentiles on daily presence occur between 01-Jan and 05-Dec), whereas NARW were present in the Cabot Strait (ca. 50°N) for eight months, from May through December. This assessment of range-scale variability in NARW vocal presence demonstrates the potential of PAM to facilitate efficient monitoring and sustainable management of the species.

Combining near-field acoustic records and genetic identity of an individual eastern North Pacific blue whale off the central Oregon coast.

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Populations of blue whales worldwide have been described from acoustic calls and genetic markers. Although these data sources have been used independently to assign individual whales to a population, a direct link between call signal structure and genetic identity remains undescribed. The question remains, what is the concordance of acoustic call types with genetically identified populations, given call variability? Here we present acoustic records and a genetic profile of a blue whale sampled ~27 miles offshore of Oregon. One of two sighted whales was biopsied, while their vocalizations were recorded using a drifting hydrophone. An assignment test using a DNA profile consisting of mtDNA haplotype, sex, and up to 15 microsatellite loci identified the whale as male and confirmed an eastern North Pacific (ENP) origin through comparison to reference databases. A spar buoy with a suspended hydrophone (High-Tech Inc.) was deployed ~50 m from the whales, producing a 68.7-min record containing 28 “B” and 6 “A” calls with prototypical ENP blue whale call structure. Maximum call received levels were ~110 dB re µPa2-Hz-1 at ~90 Hz. Assuming 187 dB as a call source level, this received level implies a signal loss of ~77 dB, and thus a ~7 km range from the hydrophone to the vocal whale. GPS tracking shows the boat remained in an elliptical area (r~10 km) while circling the pair, consistent with the sampled whale as the call source. Although it is not possible to confirm the identity of the calling whale, our results are consistent with previous studies showing the ability to link acoustic call types and the whale’s sex, while offering the potential to assign an individual to a population. We plan to link acoustic information and genetic identity from a larger dataset of blue whales from southern California to better understand their population structure.

Sex, age, and hormone correlates of phthalate exposure among common bottlenose dolphins (tursiops truncatus) from Sarasota Bay, FL

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Phthalates are a class of manmade chemicals added to personal care products, cleaning products, cosmetics, and plastics to enhance properties such as lubrication, flexibility, and fragrance. Phthalates are of increasing concern to human and environmental health because of their ubiquitous use and potential for endocrine disruption. Phthalates are easily metabolized and excreted in urine, thus monitoring for urinary phthalate metabolites using liquid chromatography/tandem mass spectroscopy is indicative of exposure to parent compounds. Recently, a pilot study reported phthalate exposure in 71% of bottlenose dolphins sampled in Sarasota Bay, FL (N=17; 2016-2017), suggesting prevalent environmental exposure. The most frequently detected metabolites (monoethyl phthalate, MEP; mono-2-ethylhexyl phthalate, MEHP) were from parent compounds added to personal care products and plastic, with concentrations sometimes exceeding reported levels for humans (geometric means: total phthalates = 2.9 ng/mL; MEP = 5.4 ng/mL; MEHP = 1.0 ng/mL). In humans, phthalate exposure can vary by age and sex; however, variation relative to demography is currently undetermined for bottlenose dolphins. Similarly, endocrinological impacts are unknown. To address these knowledge gaps, comparisons of phthalate metabolite concentrations between age classes (i.e., juvenile vs. adult) and sexes will be performed (Mann Whitney U test, α=0.05) using urine collected from bottlenose dolphins sampled during additional years of Sarasota health assessments (2011-2019). Additionally, associations between serum hormone concentrations (e.g., thyroid, testosterone, estradiol) and urinary phthalate metabolites will be evaluated using correlation tests (α=0.05). To our knowledge, this is the first study to explore these relationships in free-ranging cetaceans. Additionally, this work provides potentially critical context for preliminary findings of phthalate exposure in Sarasota Bay dolphins by examining demographic differences in exposure and relationships with established biomarkers of dolphin health.

First report on Antarctophthirus microchir (Anoplura: Echinophthiriidae) from free-ranging "urban" South American sea lions (Otaria flavescens) by using a novel non-invasive method.

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Consisting of five different genera, the family Echinophthiriidae belongs to the phthirapteran suborder Anoplura, the sucking lice, and exclusively parasitize mammals with a semiaquatic lifestyle, such as pinnipeds and the North American river otter. Findings of *Antarctophthirus microchir* were reported from all six species of the subfamily Otariinae, the sea lions, showing a wide geographical distribution in both hemispheres. Between March and May 2018, an "urban" bachelor group of South American sea lions (*Otaria flavescens*) living in a freshwater biotope of the southern city Valdivia, Chile, was examined for their ectoparasite fauna applying a novel non-invasive method for parasitological research in marine mammals. Therefore, a lice comb, screwed on a telescopic rod and fixed with Tesa® tape, was used for epidermal sample collection (fur coat hair, lice, nits and skin tissue samples) from living animals. During sample-taking process, *A. microchir* was detected in 4/5 individuals. Interestingly these specimen were exclusively found at the junction between the back and hind flippers. The current findings constitute the first report of *A. microchir* infestation in this unique synanthropic colony of South American sea lions. Findings on different life stages proved the complete life cycle of *A. microchir* to occur on this bachelor group, despite inhabiting a freshwater habitat and in absence of females or pups. The non-invasive "telescopic lice comb" opens new possibilities to collect epidermal samples, such as fur coat hair, lice, nits and skin tissue, for a wide spectrum of research without troubling the animals.

Monitoring small cetaceans using passive acoustics to inform cross-border conservation efforts

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The waters of the cross-border region between Scotland, Northern Ireland and the Republic of Ireland host internationally important populations of marine mammals. In this region, noisy or

physically disturbing human activities may pose a threat to these species. Because the impacts of these activities are not delineated by national boundaries, two European Union (EU) funded projects in this region are utilising a network of buoys to monitor and inform the conservation of protected areas and species.

Cetaceans are explicitly protected throughout European waters, and furthermore EU Member States are required to designate Special Areas of Conservation (SAC) for particular species. In addition to Northern Ireland's Skerries and Causeway SAC, Scotland recently designated the Inner Hebrides and Minches SAC, one of Europe's largest marine protected areas (MPA), for the conservation of harbour porpoises. Scotland is also working on proposals for the creation of MPAs for other cetaceans.

These protected sites will require monitoring plans, so two complementary projects, COMPASS and MarPAMM (funded through EU INTERREG VA programme), are using moored passive acoustic recorders to provide a low cost, long duration monitoring option for echolocating cetaceans such as dolphin and porpoise species. Passive acoustic monitoring using echolocation click detectors (Chelonia C-PODs) can collect data continuously for several months, to allow exploration of temporal trends which visual surveys cannot provide.

Here, the initial results from the COMPASS project will be presented and discussed, plus the opportunities of additional data from MarPAMM. We highlight general differences in occurrence between monitoring locations and some initial habitat preference modelling. We introduce the seasonal patterns in occurrence of both harbour porpoise and dolphin species, with two of the monitoring locations demonstrating some particularly high rates of porpoise occurrence, and discuss how these data might be used to inform the conservation of species in this region.

The plastic cetaceans – strandings linked to plastic ingestion around the world.

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The accumulation of plastic in the marine environment is a major threat to marine biodiversity. Species are directly impacted through ingestion or entanglement causing injury or death and associated toxicological effects cannot be excluded. Although a drastic rise in the number of reported events during the last decades has been noted for cetaceans, a clear understanding of which debris are important and the extent of impacts remain elusive, due partly to the lack of standardised procedures. Building upon recommendations from international fora, we present a review of available information detailing the ingestion of debris by cetaceans on a global scale. Evidence clearly suggests plastic bags, sheeting, food wrappers, portions of plastic bottles, disposable plates, cups, and miscellaneous broken pieces of polystyrene and other single use items are the most frequently observed marine debris found in stranded cetaceans. Portions of nettings, fishing gear, floats, monofilament lines and hooks are the most commonly found fishery-related items. The ingestion of plastic debris often seems to be a contributing factor in mortalities, although an increasing number of cases exist where large amounts of plastic within the stomach were identified as the cause of death. Identifying the type and origins of marine debris is challenging, but key to understanding the nature of the interactions between cetaceans and marine debris. In this context, this work highlights the crucial role of post-mortem examination in understanding the nature and effects of plastic ingestion on cetaceans and emphasises the necessity of adoption of standardised procedures during necropsies. Given the complex nature of marine plastic pollution, we also recognise that management policies must be inclusive of all stakeholders to match the scale and severity of the issue. Our work therefore will contribute useful information to a multidisciplinary effort to reduce the severity of plastic ingestion on cetaceans.

Modelling habitat suitability of whales in the Southern Ocean

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Detailed information on cetacean distribution is crucial to identify large-scale conservation actions and management decisions. Understanding the

ecological drivers behind their spatial patterns in the Southern Ocean is complicated by whales' mobility and the logistic restrictions in collecting data in polar environments. Species distribution models have become essential tools in ecology and conservation. They relate information on species occurrence with environmental predictors thought to influence its habitat use, to predict its potential distribution and explain environmental drivers of the observed patterns.

In this study, we compiled opportunistic presence-only data for seven whale species in the Southern Ocean from multiple sources. A quality-controlled data set was then used to model species distributions using Maxent software (under the point process modelling framework). Environmental predictors were prepared from multiple *in-situ* and remotely-sensed sources, based on our experience of the study area and species ecology. We estimated the best combinations of Maxent's parameters & evaluated model performance on a species-specific spatial block cross-validation to maintain spatial independence between training and testing data. For each species, block size and their spatial allocation into cross-validation folds was objectively determined according to how much spatial-autocorrelation exists at occurrences.

For each of species, we 1) predicted circumpolar potential distribution, 2) determined the most important variables, and 3) showed the relationship between habitat suitability and environmental variables. We believe that our results would be of great importance to explain the habitat preference of species in the Southern Ocean, for the first time for the majority of studied species. However, we argue that these models can only represent a hypothetical, mean state (which actually never becomes manifest) of the potential distribution of the species in space, and hence another set of dynamic models are required to consider the high dynamic environment in the Southern Ocean and the migratory nature of whales.

Occurrence of cetaceans in the Dardanelles Strait, Turkey in 2018

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The Dardanelles Strait, which is a part of the Turkish straits system connecting the Mediterranean and Black Sea basins, serves as an important transitional zone for marine life. Three odontocete species are known to occur in the area: bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*). Visual and acoustic surveys aimed at monitoring the cetacean presence in the area were conducted between March and November of 2018 from pile driving platform located near the eastern end of the strait at approximately 10 km distance from the Marmara Sea. Observations took place on 117 days resulting in a total of 308 hours and 28 minutes of visual observations and 176 hours and 40 minutes of acoustic monitoring. A total of 52 sightings of cetaceans were recorded, 43 of which were visual, and 9 were acoustic. Of the visual sightings, the individuals in 27 sightings were identified as bottlenose dolphins (*Tursiops truncatus*) and the rest of the visual sightings were unidentified delphinid species. Across the study period the highest encounter rates were recorded during the months of June and July (0.18 and 0.11 per hour, respectively). Average group size was highest in April with 11 individuals per group. It was possible to identify the behaviour of the animals for 40 of the sightings, 28 of which were feeding events, while the during the rest of the sightings the animals were observed travelling. The information gained from this study shows that the animals utilise the Dardanelles strait mainly for feeding on fish that migrate seasonally between the Aegean and Marmara seas. Further studies are needed to better understand the cetacean populations in the area in order to identify the main threats and implement necessary conservation measures.

Harbor porpoises (Phocoena phocoena vomerina) catching and handling large fish on the U.S. West Coast.

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The harbor porpoise is a cryptic species, and information on their behavior is limited. This study describes the chase and capture of large fish by harbor porpoises (*Phocoena phocoena vomerina*) in the Salish Sea off Fidalgo Island, Washington (salmonid species, 2017/2019) and San Francisco Bay, California (American Shad, *Alosa sapidissima*, 2016/2017). For all capture events similar behavior was observed; the porpoise accelerated after the fish, swimming in a circle at

the same spot, diving and coming out of the water head first carrying the fish cross-wise in its mouth. While the catch of the large prey was visible just below the surface, it remains unknown whether the porpoise eventually consumed the fish. We also document a harbor porpoise that drowned in drift net gear that had fed on salmonid species in Cook Inlet, Alaska (2014). The female harbor porpoise had a large amount of salmon (likely Pink salmon, *Oncorhynchus gorbuscha*) in her stomach and sticking out of her mouth. Salmonid species and American Shad have not been documented as prey items for harbor porpoises along the U.S. West Coast and Salish Sea, despite diet studies that have spanned over 30 years. These species are, on average, larger than typical prey species known to be consumed by harbor porpoises. The morphology of the upper respiratory tract in odontocetes may make them more vulnerable to an esophageal obstruction by large prey items that can lead to asphyxiation, and indeed cases of harbor porpoises dying from asphyxiation have been documented. As harbor porpoises have a very high metabolism, the high nutritional pay off may be worth the possible risk of catching a larger prey item. Little is understood about wild harbor porpoise behavior and reports such as this helps to better understand their behavioral repertoire and ecological relationships.

Physiological and behavioural responses of wild harbour porpoises to a commercial seal scarer

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Increasing noise levels from human activities at sea have diverse effects on marine mammals, varying from masking of signals to stranding of animals. Still, it is less known if noise induces physiological responses. Acoustic deterrence devices, such as seal scarers (SS), are increasingly used to deter animals from fishing gear, and to displace animals away from pile driving operations to avoid hearing damage. Even so, little is known about the extent of behavioural disruption and physiological stress they may cause. Here, we investigate the fine-scale physiological and behavioural responses of harbour porpoises exposed to a commercial SS (Lofitech, Norway) in inner Danish waters. Harbour porpoises bycaught in pound nets were tagged with suction cup-attached DTAGs recording electrocardiogram, sound, and movement (GPS, depth, 3D-accelerometry, 3D-magnetometry). 15 minutes after release, animals were exposed for 15 minutes with received levels of 110-138 dB re 1µPa RMS, resembling levels at distances up to 9 km at sea, assuming spherical spreading. They responded strongly to the SS by increasing fluking rate and speed, swimming either near the surface or bottom. Concomitant heart rate measurements showed an increased from 60 to 160 beats min-1 while the porpoise was breath-holding, presumably due to the increased exercise of the avoidance response. One porpoise immediately reduced biosonar click output levels by 10 dB during exposure, greatly reducing the detection range of obstacles such as fishing gear. We thus demonstrate that sound exposure can directly or indirectly evoke significant physiological responses in cetaceans, which may profoundly impact blood gas management and breath-hold capability. We conclude that harbour porpoises react strongly well beyond 1 km from the SS, where risk of pile driving induced hearing damage is very small. Future use of lower SS source levels will therefore achieve the desired deterrence of porpoises while reducing risk of undue negative effects.

Under pressure – Surviving 10 years of human impacts on the smallest population of dolphins in Southern Africa – Namibia's common bottlenose dolphins

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Namibia is home to a small, isolated population of bottlenose dolphins, subject to a range of threats including mariculture, boat-based tourism and harbour construction. We summarise findings of a decade of research by the "Namibian Dolphin Project" in Walvis Bay, a key habitat within the dolphin's range. We apply a multi-disciplinary and cost-effective approach including land and vessel-based surveys, photographic mark-recapture, focal behavioural follows, long term static acoustic monitoring and strandings response. The population numbers around 82 individuals based on photographic mark-recapture estimates (2008-2012), with no clear population trend (Elwen et al. 2019). Strong social subdivisions are apparent, with groups exhibiting differential habitat use. SOCPROG network analysis indicates a small semi-resident group dominated by young males and

a larger group dominated by breeding females, the latter observed more regularly during prey-rich winter seasons (Indurkhya, 2012, Pouplard 2015). Within Walvis Bay, clearly differentiated feeding and resting areas (Jylhä-Vuorio 2017) have remained stable but area use within the bay has constricted concurrent with increasing anthropogenic impacts. Foraging during low-productivity summers often occurred around oyster farms, suggesting an 'artificial reef' effect. The acoustic repertoire is divided into 7 broad sound types (Gridley et al., 2015) with repertoire richness strongly related to behavioural activity, group size and dispersion (Badenas 2015). Whistle frequency and duration reflect emotional arousal and a response to tour boat presence (Heiler et al. 2016). A catalogue exceeding 50 stereotyped signature whistle types has been identified though the SIGID bout analysis approach (Janik et al., 2013). From this, acoustic mark-recapture has been tested to understand individual movement. Development of spatial capture-recapture (SCR) using acoustic labels is underway. The population has shown remarkable resilience during a decade of increasing impacts. However,r the small size and behavioural adaptions shown indicate its longevity remains on a conservation knife edge.

Eavesdropping on Northern Resident killer whales: Passive acoustic monitoring reveals overlap with endangered Southern Resident killer whales in proposed critical habitat.

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Resident killer whales are primarily known from their predictable occurrence in the inland waters of Washington and British Columbia, but little is known about their occurrence in coastal waters. As a part of an effort to examine year round movements and identify critical habitat for endangered Southern resident killer whales, autonomous passive acoustic recorders were deployed at fifteen sites spanning the Washington coast from 2015 to 2017. While the primary focus was to monitor endangered Southern resident killer whales, both northern (NRKW) and southern resident killer whales (SRKW) were detected throughout the year. SRKW were detected on 213 days at ten locations, whereas NRKW were detected on 135 days at seven locations during the same period. NRKW were detected in every month of the year, while SRKW were not detected during the month of August. Occurrence peaked from March to May for both populations, with a smaller peak in late summer/early fall. 90.4% of NRKW detections were at the northernmost sites, while only 21% of SRKW detections were at these sites. SRKW were most frequently detected at nearshore sites (84% of all detections), while the majority of NRKW detections were at mid-shelf and deep sites (96% of all detections). A suite of measures of sound production was further analyzed to investigate differences in acoustic behavior between the two populations, and no significant differences were found. Previous studies have indicated that Chinook salmon is the preferred prey of both NRKW and SRKW, and the temporal overlap of both populations may indicate that they are targeting the same salmon runs returning to their natal rivers. As the southernmost resident killer population, SRKW have the narrowest selection of Chinook salmon available to them. It is important to understand the role that competition may play in limiting the recovery of SRKW.

Diving behavior and movements of a Sowerby's beaked whale tagged near Norfolk Canyon

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The Virginia Capes (VACAPES) Operating Area offshore of North Carolina, Virginia, and Maryland plays a vital role in the U.S. Navy's training and testing operations given its complex bathymetry and proximity to the world's largest navy base, Naval Station Norfolk (NSN). Advancements in satellite-monitored tagging technology allow scientists to improve their understanding of marine species including cryptic beaked whales that occur in these waters. In September 2018 during a multi-year U.S. Navy-funded survey to provide a more detailed assessment of species occurrence, diversity, and habitat use near the continental shelf break and Norfolk Canyon, a group of three Sowerby's beaked whales (*Mesoplodon bidens*) was sighted 125 km from shore in 1,219 m of water. During the encounter a Wildlife Computers SPLASH10 dive/location LIMPET-configured tag designed to collect medium-scale movements and

dive behavior was deployed on an adult Sowerby's beaked whale. This was the first 'dart' tag deployed to date on this species across all oceans. Over the course of the 14-day tag duration, the individual travelled primarily over deeper (>1000m) waters east of the outer continental shelf break to the north approximately 135 km from the original tagging location near Norfolk Canyon. A total of 123 dives were recorded with 52 considered foraging deep dives (mean dive depth = 738 m) and 71 classed as non-foraging shallow to mid-water 'bounce' dives (mean dive depth = 220 m) based on strong similarities in diving patterns to other species of beaked whales. Mean foraging dive duration was 30 min, mean bounce dive duration was 14 min, and mean surfacing event was 6 min. Information gathered to date provides researchers and regulators with a vital glimpse into multi-day movement and dive behavior by such a challenging to study species.

Intensive illegal hunting of the African manatee (Trichechus senegalensis) for subsistence and traditional medicine in southeastern Nigeria, West Africa.

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African manatees were once common in river systems of southeastern Nigeria, but now are mostly only seen when killed for bushmeat. Due to the difficulty of studying this shy species in numerous waterways, very little is known about its biology or ecology, and threats have never previously been quantified in Nigeria. From October 2008 to September 2018, we conducted intensive threat surveys combined with undercover investigations of manatees hunters' activities, seasonal trends, the manatee bushmeat trade and consumption patterns in three range states (Akwa Ibom, Cross River and Rivers) focusing particular attention on three river systems: the Cross, Qua Iboe and Imo and their tributaries, creeks and associated flood plains that all empty into the Atlantic Ocean. Our results reveal intensive and unsustainable poaching across the region for the expanding bushmeat trade for subsistence and commerce, traditional medicines, other cultural beliefs and sorcery. African manatees were also killed during industrial development and urbanization in some critical habitats. Overall, illegal hunting pressure increased steadily from 2010 to 2017 with a peak in mid-2016. Over the decade of this study we recorded 104, 31 and 66 manatees killed and traded in the Cross, Imo and Qua Iboe Rivers respectively. We documented an expanding market in northeastern Nigeria with the value of manatee meat increasing from 60,000 naira in 2008 to 400,000 naira in 2018, indicating that manatee meat consumption is increasing while the population is likely in rapid decline. Based on our results, we believe the current trend of manatee poaching and trade is likely to drive the species towards extinction in this region unless serious conservation actions are taken to reverse it. The results of this study will be used to work with and strongly encourage Nigerian government wildlife authorities to enforce existing laws and regulations protecting the species in Nigeria.

Yawn-like behavior in Tursiops spp.

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Yawning is an involuntary action, which starts with slow gaping and inspiration (phase-1), maintaining maximum opening of the mouth for a while (phase-2) and ends with quick closure of the mouth following expiration (phase-3). Yawning has been widely reported in vertebrates, suggesting yawning as an evolutionarily conserved behavior. Here we report yawn-like behavior in captive and wild bottlenose dolphins (*Tursiops* spp.) underwater without inspiration and expiration which does not fit the classical definition of yawning. In a seventeen-day (119 h) observation of three captive bottlenose dolphins in Minamichita Beach Land, Japan, 1814 cases of mouth-opening behavior were reported. Obvious intentional behaviors (e.g. threat from other dolphins or human visitors) and short mouth-opening behaviors (< 0.3 s) accounted for 246 cases of unintentional mouth-opening activity. We then selected 54 mouth-opening activities with phase-1 duration > phase-3 duration (definition of human fetal yawning). Ten naive observers reported 5 yawn-like activities as described by Human Observer Classification Method. These 5 yawn-like actions were characterized by maximum

gaping along with phase-1 being longer than phase-3. Level of physical activity was low within 20 minutes before and after yawning, suggesting that dolphins yawn during drowsy states like humans. Five cases of yawn-like behavior were observed in 386-day (1816 h) underwater videos of wild Indo-Pacific bottlenose dolphins, Mikura Island, Japan, using the same attributes of yawn-like behavior, viz. maximum gape and phase 1 > phase 3. No significant differences were found between captive bottlenose dolphins and wild Indo-Pacific bottlenose dolphins in total durations as well as each phase. It may be concluded that bottlenose dolphins exhibit yawn-like behavior without respiration, which is supported by the "arousal hypothesis" of human yawning.

Humpback whale call use across time, space and context.

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Recent studies have investigated whether humpback whale non-song sound types ("calls"), which are produced by both sexes and all age classes across the migratory range, may be transferred genetically. Certain humpback whale call types are shared by allopatric populations and some are stable across years and decades, indicating that some calls may be fixed within the humpback whale repertoire. However, the repertoires of many humpback whale populations, particularly at high latitudes, have not been described, and a comparison of call types between allopatric populations in contrasting points on the migration (i.e., breeding and foraging grounds) has not been conducted. The first goal of this study was to classify the humpback whale call repertoire on the Newfoundland foraging ground and investigate inter-annual repertoire stability using recordings from 2015 and 2016. The second goal was to compare calls from the Hawaiian breeding ground in 1982 to those from the Newfoundland foraging ground in 2015, to determine whether five call types (whups, growls, swops, droplets, teepees) are shared between discrete, allopatric populations. To meet these objectives, we manually classified calls into types and then used classification and regression tree analysis and random forest analysis to validate manual classifications. The five call types were identified in the Hawaii dataset as well as in both Newfoundland datasets, and at least two other call types were found in both Newfoundland datasets that have not been previously described. Use of the five call types on a contemporary feeding ground and a historic breeding ground supports the hypothesis that some calls are innate, while the occurrence and stability of these five call types supports the hypothesis that certain call types are fixed in the humpback whale repertoire. In addition, findings provide further evidence for call types that may be useful for global passive acoustic monitoring efforts.

Variations on the same theme: Bowhead whale versatility and stereotypy within a song sharing framework.

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Bowhead whale singing behaviour has been studied for more than 3 decades and recently researchers described an unprecedented song repertoire diversity that rivals those of the most prolific songbirds. Unlike the better studied humpback whales, bowhead whales do not appear to share songs at the population level, but several studies have reported song sharing at a reduced scale of several individuals. However, there has been little discussion to date regarding variability and stereotypy in bowhead whale singing display and how this influences our understanding of the acoustic ecology of this endangered species. Here, we present 13 song groups sharing similar hierarchical structure and units from an unstudied wintering ground off Northeast Greenland. Semi-automated procedures assisted in identifying unit types and in exploring patterns of variability both at the song structure and at the unit level. Multidimensional maps performed well at defining unit types, showing 15 well separated clusters corresponding to units labelled manually, and revealed the presence of subtypes. Song groups presented variability in unit diversity, ranging from 2 to 6 units per song, and consistency in the association of units in 2 main phrases. Different units presented either high or low degree of variability over their acoustic parameters, suggesting that bowhead whales keep consistency in some units while using a continuum in frequency and modulation parameters for other unit types. Our results demonstrate that bowhead whales can

display contrasting levels of variability inside a shared song framework. Those findings emphasize the need to account for variability in song analysis and indicate that shifting from song toward units or phrase-based analysis as it has been suggested for humpback whales, could allow to identify and track similarities in songs over larger temporal and geographical scales.

Effects of cold on skin temperature in Florida manatees (Trichechus manatus latirostris).

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Cold stress is one of the major threats to Florida manatees. Every year Cold Stress Syndrome (CSS) affects and kills Florida manatees during prolonged or intense cold weather periods. In contrast to other marine mammals, manatees lack essential thermoregulatory anatomical and physiological adaptations: sparse thermal insulation, the lack of arteriovenous anastomoses in the skin, and limited capabilities for shivering/non-shivering thermogenesis are only a few of the causes for sensitivity to cold.
So far, CSS has been associated mainly with exposure to water temperatures below approximately 20°C. However, the impact of low air temperatures on manatee physiology and manifestation of cold stress is not known.
In a long term study we have been investigating the impact of air temperature on skin temperature in two adult male Florida manatees, held in an outdoor sea water tank at constant water temperature. For 2.5 years and under varying environmental conditions we have been collecting skin temperature measurements at 25 spots distributed across the entire body surface. Measured skin temperatures in the smaller, more active individual have been consistently higher than those in the larger less active manatee. Within individuals, average temperature varied by less than 1°C between measuring spots. Interestingly, the temperature distribution pattern between measuring points has been congruent in both individuals. This congruent and consistent temperature pattern is another indicator for manatees' lack of control of peripheral heat loss, causing their low tolerance of cold. The pattern may reflect underlying anatomical conditions, such as distribution, number and size of blood vessels, and distribution of blubber composition and thickness, requiring further investigation.
Our measured values indicate an impact of air temperature on skin temperature in both manatees. However, more cold air data are necessary for a sound conclusion, which we anticipate to obtain during the coming winter.

A new cetacean monitoring programme along fixed transect using ferries as platforms in the Strait of Gibraltar

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Since January 2018, fixed transect surveys for monitoring cetaceans in the Strait of Gibraltar were carried out using ferries as opportunistic platforms. The Strait is an Important Marine Mammal Area (IMMA) as well as one of the busiest areas for maritime traffic in the Mediterranean. Presence of cetaceans was monitored along the two ferry routes Algeciras-Ceuta (A-C) and Algeciras-Tanger Med (A-T), following the approach proposed by the "Fixed Line Transect using ferries as platform for observation in the MEDiterranean network" (FLT MED). At least two trained observers located on the bridge of the ferries were scanning both sides of the vessel, encompassing an angle of 180° and recording cetacean sightings. Five surveys per season were undertaken during the year for both routes with a minimum of one survey per route each month, depending on sea conditions and platforms availability. From January 2018 until March 2019, 2381.75 km for a total of 68 hours on effort were travelled on 35 routes (20 of the route A-C and 15 of A-T). Overall 142 encounters of around 3109 animals were logged. During surveys, 7 species of cetaceans were identified on both routes, short-beaked common dolphin was the most common one followed by striped and bottlenose dolphin, short-finned pilot and sperm whales. Fin and killer whales were encountered just along the transect A-T. Moreover, 44 and two sightings of unidentified small- and medium-sized cetaceans were also logged. Preliminary results show a high encounter rate along the routes in the IMMA Strait of Gibraltar highlighting the benefits of using ferries as platforms for research, enabling systematic year-round monitoring over large spatial scales at low cost.

Five years studying blue whales in Southern Chile.

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Blue whales (*Balaenoptera musculus*) are the largest cetacean species and as such, they were major targets of the whaling industry, which led to tremendous declines in their populations during the 20th century. It is estimated that their population was depleted as much as 90%, resulting in an Endangered listing by the IUCN. In this period, more than 4000 individuals were caught in Chilean waters. Nowadays, the greatest abundance of blue whales in Chile is in Northern Patagonia, in the Chiloense Ecoregion (CE). This region is one of the most important blue whales feeding and nursing grounds discovered to date in the Southern Hemisphere.

Between 2014 and 2018, 5 scientific expeditions collected information to study the ecology, foraging and acoustic behaviour of blue whales in the Gulf of Corcovado (CE). Photo-identification allowed identification of 79 blue whales, with some site fidelity. Some animals were found to be in poor body condition. Twenty three blue whales were tagged using digital acoustic tags (DTAGs) to analyse their diving; maximum depth was found to be 139 meters. Acoustic data on tags were also analyzed, and a method to identify the calling individual using accelerometers was proposed. Genetic analysis of 30 samples identified 13 male blue whales, 10 female blue whales and 7 non-determinates. Prey mapping was done during focal follows of tagged blue whales, identifying aggregations of zooplankton in the middle of the water column (during daytime hours), typically in a layer between 40 and 100 m depth. Chemical and physical profiles of the water column indicated that most sightings have been in areas with a stratified water column with freshwater influence (lower salinity).

Finally, our surveys have shown great biodiversity, with more than 11 species sighted or detected by acoustic recorders, showing that this area is important habitat for marine mammals in Chile.

MISTIC SEAS II: Designing and implementing pilot monitoring programmes for cetaceans in Macaronesian waters.

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The project MISTIC SEAS I selected common species and Management Units (MUs) in European Macaronesia islands (Azores, Madeira and the Canary Islands) and defined thresholds and environmental targets to help determine the Good Environmental Status (GES) of this functional group in Macaronesia following the requirements of the Marine Strategy Framework Directive (MSFD). MISTIC SEAS II, designed and implemented pilot monitoring programmes to estimate abundance baseline values of those MUs. Those programmes aimed: (a) COASTAL, examining a Robust-design mark-recapture sampling framework for bottlenose dolphins and (b) OCEANIC, testing line-transect sampling methodology to obtain design and model-based abundance estimates for spotted dolphins. Mark-recapture abundance estimates of bottlenose dolphin were 640 individuals (CV 0.25) for Azores, and 164 (CV 0.03) for Madeira. Insufficient sightings were available for the Canaries. Mark-recapture estimates were also obtained for short-finned pilot whales in Madeira and Canaries. Results of the OCEANIC program allowed obtaining the first baseline estimates for Azores and Canaries, and updated values for Madeira. Model-based abundance estimates of Atlantic spotted dolphins were 2,324 individuals (CV 0.15) for Azores, 34,851 (CV 0.18) for Canaries and 725 (CV 0.41) for Madeira. Further abundance estimates were obtained for another fifteen species or group of species for which there were enough sightings, although not for all archipelagos. A STRANDING programme analysed the strengths and weaknesses of the existing stranding networks, suggested improvements and designed protocols for life-history analyses. Vessel collision was the main anthropogenic cause of death in the Canary Islands, primarily for sperm whales. Project results were used to assess GES in Macaronesia, and reported as part of the MSFD second cycle. In addition, the project demonstrated the feasibility of implementing the pilot monitoring programmes and provided common protocols and additional information on distribution, habitat use and on the threats faced by cetaceans in the region.

Interactions between the south american sea lion and pair trawl fishery in southern brazil

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The southern coast of Brazil is a foraging ground and resting site for South American sea lions (*Otaria flavescens*). Strandings of sea lions are frequent and part of this mortality is associated with fisheries interactions. The aim of this study was to describe the interactions between *O. flavescens* and the bottom pair trawl in southern Brazil. Twenty three fishing trips were surveyed by observers onboard pair trawl vessels operating in the continental shelf, from the Uruguayan border (33º44'S) to Laguna (27º52'S), between November 2011 and April 2019. A total of 1048 sets, in depths ranged from 10 to 83 meters, were recorded. The interaction was registered in 46% of the sets, with a mean of 5.3 sea lions/set (SD= 5.0). The interactions were observed in all seasons, but in the austral summer the number of sets with interaction was higher (48%) and lower in the spring (12.4%). On the other hand, the average number of sea lions/set was higher in spring (6.2 animals/set) and lower in winter (4.1 animals/set). In most of the sets (74%) the interaction occurred during the day. The interactions occurred during the hauling, where in 92% of these events, the sea lions were eating the fish trapped in the net or discarded. Damage to the net occurred in four sets only, but without significant loss of the catch. Furthermore, we recorded incidental captures of 12 dead and one alive specimens of *O. flavescens*, four males (Total Length (TL)= 116, 150, 186 e 193cm), seven females (TL= 111, 149, 156, 174, 174, 177, 182cm) and two individuals of unidentified sex. The interactions between *O. flavescens* and pair trawls are frequent and occur throughout the year, with few losses in catches. These interactions represent a threat to this species due to the high fishing effort in the region.

Abundance and site fidelity of common bottlenose dolphins off a remote oceanic island (Reunion Island, southwest Indian Ocean)

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This study represents the first comprehensive assessment of the common bottlenose dolphin

population dynamics and residency around Reunion Island (southwest Indian Ocean). Understanding the dynamics and movement patterns of this local population is essential to guide effective conservation efforts, notably in a context of growing dolphin-watching activities. Dedicated surveys based on photo-identification method were conducted over a 6 years period (2010-2015). The species was present year-round, in groups of 24 individuals on average (1-150). Jolly-Seber mark-recapture models resulted in a population estimate of 256 individuals (95%CI = 193 - 340) and an annual apparent survival rate of 0.83. Three main residency patterns were described: residents (29.0%), occasional visitors (56.2%) and transients (14.8%), suggesting that the majority of the population showed a moderate-to-high level of residency in the study area. Models based on the lagged identification rate indicated emigration and re-immigration to the survey area, with some individuals occupying the study area for 3-4 years (1333 days), and remaining outside for an average of 635 days, probably exhibiting larger home range and extensive movement behavior. Genetic studies and comparison of bottlenose dolphin photo-identification catalogues among Mascarene Islands (Reunion Island, Mauritius, Rodrigues) and Madagascar would help understanding the level of dispersal and connectivity among local populations from the southwest Indian Ocean, and hence assessing the level of vulnerability of the Reunion population.

The challenges for assessing favourable conservation status in coastal bottlenose dolphins

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Under the EU Habitats Directive, European Member States are obliged to designate sites as Special Areas of Conservation (SACs) for the maintenance, at a favourable conservation status, of particular vulnerable species, within their territorial waters. One such species is the bottlenose dolphin, with emphasis upon coastal populations given their increased exposure to human pressures and the fact that they often exist as small, apparently discrete populations. Determining whether a species is at favourable conservation status requires an assessment of population trends. Using two survey approaches (visual line transects by vessel with Distance sampling and Photo-ID Capture-Mark-Recapture studies), trends in bottlenose dolphin abundance are examined over an 18-year period both within and beyond two designated marine protected areas. Numbers using the sites have fluctuated over the last two decades, the time period over which an assessment is made profoundly affecting any conclusions reached over trends observed. Furthermore, the two methods yielded different patterns of variation. Photo-ID studies provided estimates with lower CVs especially when a Robust Design model is used that allows for the population to be open to immigration and emigration. Movement, not only between but also within years, occurs between the SACs and the wider region. This highlights the importance of determining population structure at the appropriate spatial scale, since even within the study area, groups of animals show different degrees of site fidelity and movement. Although a recent decline has been observed, the change in numbers over the last ten years has not reached the 30% threshold advocated for assessment whether the species in the region is no longer at favourable conservation status.

Temporal stability of social behavior in bottlenose dolphins (Tursiops aduncus)

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Interest in stable behavioral phenotypes has shaped studies of both human and non-human animal behavior, and more recently evolutionary processes. In particular, social phenotypes are emerging as critical drivers for disease spread and information transfer as well as fitness, and thereby

have a major impact on populations. Yet the stability of behavioral phenotypes, essential by definition, has rarely been measured over developmentally significant lengths of time. Here we investigate the stability of social phenotypes in individual wild bottlenose dolphins (*Tursiops aduncus*) from infancy to adulthood, and within the adult period, spanning decades. Using survey data from a 36 year study of Shark Bay dolphins, we quantified several measures of social behavior for 51 dolphins (32 females, 19 males) who have been sighted extensively from infancy to adulthood (≥20 surveys per life history period). While repeatability differed by measure, we found clear evidence that individuals exhibit stable social phenotypes through long periods of time. The percentage of time an individual spent alone and the percentage of time in large groups (>7 dolphins) were highly repeatable across life history stages ($r = 0.74$ and 0.76, respectively), while time in small groups (2-6 dolphins) showed negligible repeatability ($r = 0.13$). We also found that social strategy was influenced by age class and sex. Calves spent more time alone than juveniles or adults ($p < 0.01$), and females spent more time alone than males ($p < 0.001$). Males also spent more time in large groups than females ($p < 0.01$). Social phenotypes may also interact with ecological specializations. Several ecotypes (such as sponging, a case of tool use) are also stable over decades, at least among females. This is the first study to demonstrate stable social phenotypes in a wild cetacean, and is a critical addition to long term data on behavioral phenotypes.

Heavy metals in bones from Harbour Porpoises (Phocoena phocoena) from the Western Black Sea Coast

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During the last few years, the Western Black Sea coast has documented increase in the number of stranded marine mammals, particularly the harbour porpoise (*Phocoena phocoena*). This species is subject to threats such as exposure to contaminants, fishery by-catch and introduced new marine species. The aim of this study was to analyse spatial and age trends in bone metal concentration in harbour porpoises from the Western Black Sea Coast. Selected heavy metals (Cu, Pb, Zn, Cd and Ni) were measured in bones of 33 harbour porpoises stranded along the Bulgarian Black Sea Coast from 2017. Spatially, we found higher metal levels in the harbour porpoises stranded in the Northern region compared with those from the Southern region. The effect of aging was evident only for Zn content – the levels were higher in juveniles than in adults. The obtained results suggested that heavy metal contamination represent an important threat encountered by harbour porpoises.

Genetic structure analysis of northern fur seals (Callorhinus ursinus) using MIG-seq method.

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The northern fur seal (*Callorhinus ursinus*) is widely distributed across the North Pacific, and a portion of the species feeds in the waters around Hokkaido, Japan, from winter to spring. Recently, the fishery damage caused by this species has increased around Hokkaido, and management measures are needed. To address this problem, it is necessary to clarify their genetic background for the management. Although the species has been considered as one population based on previous population genetics studies, this conclusion might be due to the small number of polymorphic markers used. In this study, population genetics analysis was performed using the multiplexed inter-simple sequence repeats genotyping by sequencing (MIG-seq) method on subsamples of six populations (Tyuleny; n = 16, Lovushiki; n = 16, Srednego; n = 16, Bering; n = 16, Bogoslof; n = 16 and San Miguel island; n = 15) used in previous reports. This method provides genome-wide single-nucleotide polymorphism genotyping using the next-generation sequencing platform. 161 polymorphic sites under Hardy-Weinberg equilibrium were detected. The STRUCTURE analysis, which used all specimens, yielded the highest delta K value of 5.87 for K = 2 (delta K values for K = 3 to 5 ranged from 1.85 to 3.47), whereas the value of K with the highest log-likelihood was K = 2 (log-likelihood = -16207; those for K = 1 and K = 3 to 6 ranged from -16759 to -16262), indicating the presence of two genetic groups (Evanno et al. 2005). By comparison,

previous research, using seven polymorphic microsatellites, suggested K = 1. Our results suggest that the MIG-seq method is more suitable for determining the origin of northern fur seals visiting Japan.

No free lunch: Estimating the biomass and ex-vessel value of target catch lost to depredation by false killer whales (Pseudorca Crassidens) in the Hawaii longline deep-set tuna fishery.

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False killer whales depredate bait and catch of Hawaii deep-set longline fishing vessels, resulting in economic losses for the fishery and increasing the likelihood of hooking or entanglement of whales in fishing gear. Observers from the National Marine Fisheries Service monitor 20% of all trips in this fishery and collect data on depredation and bycatch of marine mammals. Odontocete depredation on captured fish is distinctive and can be scored reliably by observers. Typically, the entire fish posterior of the gills is consumed, leaving the head attached to the gear. Our goal in the present analysis was to estimate the biomass of fish lost to odontocete depredation and associated economic losses to the pelagic longline fishery. Depredation occurred in 6% of sets from 2004-2017, involving a total of 12,577 hooked fish. Most (61%) depredated fish were bigeye (*Thunnus obesus*) or yellowfin (*Thunnus albacares*) tuna, followed by dolphinfish (*Coryphaena* spp.), billfish (Istiophoridae spp.), and wahoo (*Acanthocybium solandri*). We used length-weight relationships from intact fish caught on the same or nearby sets to estimate the biomass of depredated fish. We estimate that an average of 71.8 metric tons (range 45.0 – 104.0 t, sd = 19.0) of tuna was lost to depredation by odontocetes annually from 2004-2017. Using available market records from the Honolulu tuna auction, we estimate that odontocete depredation cost the fleet an average of USD 840,890 (ex-vessel value) per year from 2012-2017 (range USD 693,910 – 1,025,783, sd = 148,010). These losses do not account for the opportunity costs associated with depredation of bait nor the time and expenditures of additional fishing effort to make up for lost catch. We discuss our results in the context of overall longline fishing in the central North Pacific, where the US fleet represents 5-10% of total fishing effort.

Fine-scale oceanographic drivers of foraging in California blue whales

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Animals integrate information from their environment to find food, but the environmental cues that drive this process are difficult to study and remain less understood. At broad spatial scales (e.g. the California Current), blue whale (Balaenoptera musculus) movement may be driven by memory, yet blue whales are known to target highly dynamic prey patches at fine spatial scales. To better understand how movement and sensory processes connect across different temporal and spatial scales, we analyzed surface location, diving, temperature and feeding data from 9 high-resolution multi-sensor tags (mean duration 14.34 days) from 2016-2018 to quantify blue whale foraging in relation to fine-scale oceanographic features measured by concurrently sampled high frequency radar (2-6 km, hourly resolution) along the California Coast. We show that blue whale feeding bouts were associated with anti-cyclonic oceanographic features (i.e. negative sea surface vorticity) at the scale of daily movements. Tag-derived dive-temperature profiles revealed that the water columns associated with negative sea surface vorticity exhibited a substantially deeper thermocline than areas of positive vorticity, implying that localized downwelling may be an important foraging cue for blue whales. This approach will now be applied to a larger dataset that includes 64 individual tag deployments from 2014-2018 to validate these findings and test other variables. These results give insight into the drivers of animal movement at sub-daily scales and may have important implications for spatial ecology and conservation of endangered marine species.

Persistent Organic Pollutants and Mercury in estuarine coastal bottlenose dolphins (Tursiops truncatus) of the Gulf of Guayaquil, Ecuador: A first ecotoxicological assessment.

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The bottlenose dolphin is the most common cetacean found in the coastal waters, estuaries and mangroves of Ecuador; however, as a vulnerable species, its population size is gradually declining in the Gulf of Guayaquil, where anthropogenic factors including habitat degradation, uncontrolled dolphin watching, maritime traffic, sediments dredging, bycatch and environmental pollution are suspected to affect the population health of this species. Very little is known concerning contamination by persistent organic pollutants (POPs) and mercury in bottlenose dolphins from the west coast of South America. To address this research gap, the first assessment of total mercury (THg) and POPs, including polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and polybrominated diphenyl ethers (PBDEs), in bottlenose dolphins in mangroves (El Morro Mangrove Wildlife Refuge) of the Guayaquil Gulf, was conducted in Ecuador in 2018. Using biopsy dart collection technique, nine dolphin samples (i.e. skin and blubber), were obtained for contaminant analysis. POP concentration ranged 0.60-16.4 mg/kg lw, while THg ranged 1.40-4.0 mg/kg dw. The dominant POPs were OCPs (51% of ∑POP), followed by PCBs (43.5%) and PBDEs (5.54%); particularly, *p*,*p*'-DDE, the main DDT metabolite and a potent anti-androgenic, accounted by 44% of ∑POP, ranging 0.12 to~9.0 mg/kg lw, followed by PCB 153 (8%) and PCB 180 (5%). BDE 47 accounted by 2% of ∑POP. While the POP concentrations are lower to those found in dolphins from other regions of the world (e.g., PCBs were much lower, ranging 0.3-6.0 mg/kg lw, to those measured in dolphins along the southeastern coast of USA), the THg concentrations are lower or within the concentration range found in dolphins from the USA southeastern coast. Our finding shows that bottlenose dolphins are exposed to contaminants and can be used as sentinel species of ecosystem health to monitor pollution in the region to support ecotoxicological risk assessment and inform pollutant management.

Regional variation in humpback whale song within the western Indian Ocean

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The humpback whale is one of the best-studied mysticete species, but its movement patterns within the southwestern Indian Ocean (SWIO) breeding ground are complex and yet poorly understood. Photographic identification, genetic and satellite tracking data have revealed some population structure between different sub-regions. Male humpback whales sing a song shared at the population level that is useful for defining population structure and connectivity, and thus we might expect some differentiation in SWIO song structure based upon population subdivisions. To assess this, autonomous recorders were deployed at four sites in the SWIO, off Réunion Island, northeast and northwest Madagascar, and Tanzania, during austral winter 2018 in order to define spatiotemporal patterns of song occurrence and compare song structure among sub-regions. Quality of recording and presence of songs were noted for the first 20 minutes of each hour (8083 spectrograms manually reviewed, for a total of 2694 hours of recording for the first three sites, with Tanzania currently under analysis). The daily occurrence of songs was assessed for each site to describe the temporal distribution pattern of whales. Songs were recorded from late June to early October, with higher occurrence observed in NE Madagascar. High quality samples of song sequences were selected from all sites, defining early, mid and late season periods. All phrase types recorded in Reunion were shared with Madagascar, and there also appears evident temporal variation that may be distinct to the different sub-regions. Results suggested a high connectivity between Reunion and Madagascar during the breeding season as would be expected from previous photographic and satellite telemetry data, but also the potential for introduction of novel song material into Madagascar, possibly from another population. Adding data from Tanzania, as well as further quantitative analysis will provide a better understanding of humpback whale population connectivity within the western Indian Ocean.

Preliminary estimates of vital rates from Cuvier's beaked whales on a military training range

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Vital rates are key inputs to Population Consequences of Disturbance (PCoD) models used to estimate impacts of sub-lethal stressors that may reduce fitness over time. We report preliminary vital rate data from an ongoing photo-identification study of Cuvier's beaked whales (Zc) at the Southern California Antisubmarine Warfare Range, where military sonar and explosives are tested regularly. From 2006-2018, 222 unique individuals were photographed on or near SOAR. Eighty-four whales were photographed on 2-9 separate days (mean = 3.3) and over periods of up to 11 years (mean = 3.6). Each whale was classified to age and sex each day it was photographed using genetic, life history, and visible trait data (e.g. presence of teeth, pigmentation patterns, scarring density), as available. By adapting published methods for aging and sexing Zc from photographs for use with sub-optimal photo sequences, the age and sex of only 5% of whales could not be classified with at least some confidence. The age classified sample included 86 adult females, 52 adult males, 12 sub-adult females, 22 sub-adult males, 16 unsexed juveniles, and 20 unsexed calves, as of the most recent sighting. Seventeen individuals (9 female, 6 male, 2 unknown sex) transitioned through an age class (14 sub-adult to adult, 1 juvenile to sub-adult, 2 calf to juvenile), providing sex-specific data on maturation rates. Twenty females had one calf, two had two calves, and seven mother-calf pairs were resighted together over periods from 1-954 days, providing insights into calving rates and time-to-weaning. The sparseness and variability of these data, despite concerted effort to collect them, underscores the importance of establishing photo-ID studies promptly when the need for vital rate data is apparent; it also elevates the importance of comparable long-term data from other study sites to evaluate whether vital rates for impacted populations warrant concern.

Surface drifting helium balloons posing ingestion and entanglement risks to marine mammals and turtles in the New York bight, USA.

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Global plastic production has increased from 1.5 million tons in 1950 to 348 million tons in 2017. Plastic pollution has become a major threat to the marine environment. The impact of plastic on marine mammals, turtles and seabirds has become a cause for concern as ingestion and entanglement has been recorded. This study shows the abundance and distribution of surface drifting helium balloons in the New York Bight, USA. Additionally, this study looked at the abundance and distribution of marine mammals and turtles in the same study area during the same time period. The data were collected by Protected Species Observers onboard the RV Ocean Researcher from June to December 2018 during a geophysical survey for the Empire Wind project. In the study area (321 km^2), over 791 individual balloons were counted in 628 sightings. There were 421 sightings of marine mammals and turtles resulting in a total of 2388 individuals. Sightings of marine mammals included humpback whale (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*) and gray seal (*Halichoerus grypus*). Turtle species encountered included green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) turtle. The distribution of surface drifting helium balloons overlapped with sightings of marine mammals and turtles. This poses ingestion and entanglement risks to species using the New York Bight as a core habitat or migration corridor. In conclusion, this study demonstrates the exposure of marine mammals and turtles to the high levels of surface drifting helium balloons in the New York Bight. Humpback whale, fin whale and all turtle species observed in this study are listed under the Endangered Species Act. Therefore, monitoring the impact of plastic pollution on marine mammals and turtles is essential.

Seasonal presence and annual return of female humpback whales (Megaptera novaeangliae) in the north-eastern coast of Madagascar.

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The dynamics, distribution and size of the humpback whale (Megaptera novaeangliae) population in the Southwestern Indian Ocean region remain poorly documented. The Sainte Marie channel, such as the other coastal waters in Madagascar, is one of their migration areas and was described as an important site for breeding and calving. Photo-identification data collected between 2009 and 2018 on touristic boats in the Sainte Marie channel were analyzed to determine females return rates and site fidelity to this area. The capture-recapture technique was used and the recaptures were visually identified by comparing the photos within year and between years. Females were defined by the presence of a calf beside them. A total of 2,263 unique individuals were identified from 3,386 processed photos. The results showed a very low degree of site fidelity (R = 0.017) and almost no fidelity from females (R = 3.3. 10-6). Within year recapture intervals have shown that humpback whales using the Sainte Marie channel remain on average 13 days. A total of 33% of the individuals photographed in Active Surface Groups were subsequently recaptured with calf in a mother-calf groups, showing the diversification to their social structure. The maximum recapture interval 31-days show a high degree of mobility of individuals during the breeding season. Citizen science is a basic and an accessible method for the photo identification of cetaceans, especially species frequenting coastal areas; in this study it allowed to make a first determination of the seasonal and annual presence of female humpback whales in the Sainte Marie channel. Keywords: Humpback whale (Megaptera novaeangliae), females, return rates, site fidelity, photo-identification, population dynamics, Sainte Marie channel.

Genetic diversity of Atlantic spotted dolphin (Stenella frontalis) from Southwest Atlantic Ocean and global genetic differentiation

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Recent molecular studies have shown fine-scale population structure in highly mobile cetacean species with continuous distributions despite the continuity of the marine environment. Here we assessed the genetic diversity and differentiation of the Atlantic spotted dolphin (*Stenella frontalis*), endemic to warm and pelagic waters of the Atlantic Ocean. We evaluated 463 bp of the mtDNA control region of 24 specimens from the Brazilian coast (Southwest Atlantic Ocean). Seven haplotypes were identified and haplotype diversity (*h*) and nucleotide diversity (π) were 0.7935+/-0.0662 and 0.006863+/-0.004099, respectively. One haplotype (H1) encompasses the majority of specimens (N = 10). We also compared 270 sequences of the Atlantic Ocean, the Brazilian coast (this study + three published sequences) and 243 published sequences from six other locations (Azores/Madeira, Bahamas, Gulf of Mexico, Puerto Rico, Caribbean Sea, Northwest Atlantic Ocean). We identified 122 haplotypes and the haplotype diversity was higher for Bahamas (1.0000 +/- 0.0000, n=1) and lower for Brazilian coast (0.8063 +/- 0.0501, n=27), the nucleotide diversity was higher for Northwest Atlantic Ocean (0.126364 +/- 0.061569, n=49) and lower for Puerto Rico (0.000000 +/- 0.000000, n=1). Pairwise F-statistics revealed significant differentiation among locations (Brazilian coast with Azores/Madeira, with Gulf of Mexico, with Northwest Atlantic Ocean, with Caribbean Sea; Azores/Madeira with Northwest Atlantic Ocean), and, among divisions of the Atlantic Ocean (Southwest Atlantic Ocean, Northeast Atlantic Ocean and Northwest Atlantic). These results suggest genetic isolation of the Brazilian coast population from the majority of the North Atlantic Ocean locations (east and west). These results highlight the importance of studies of population genetics in micro-scale even for species with high mobility and continuous distribution as the Atlantic Spotted dolphin.

Does common dolphin distribution respond to changes in prey availability and environmental conditions?

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Celtic Sea waters were designated as a Whale and Dolphin Sanctuary to protect their high cetacean biodiversity. The southern part of Ireland is considered a foraging hot-spot for fin, minke and humpback whales, and common dolphins, this last species being the most abundant. These top-predators feed extensively in the area on herring and sprat during autumn and winter. While the information available about the Celtic sprat stock is insufficient to assess its status, the herring stock has not recovered from the significant depletion that it suffered in 2013. Currently, the herring biomass, fishing mortality and recruitment are all outside sustainable limits. The associated fishery lost its Marine Stewardship Council sustainability certificate in 2018. The effects of these fluctuations on higher trophic levels are still unknown. The objectives of this study are to analyse spatio-temporal trends in abundance and distribution of common dolphins and prey species derived from acoustic fish surveys carrying cetacean observers over 14 years and investigate the drivers behind them. Responses of dolphins (in terms of presence and local abundance) to changes in prey availability are explored. During the study, 16.732 km of survey effort were completed and there were 1226 cetacean sightings including 796 of common dolphins. Generalized Additive Models were used to relate common dolphin sightings to environmental conditions and acoustic indices of fish abundance. While dolphin presence and sightings rate were related to several environmental variables (e.g. depth, chlorophyll concentration) no relationship was found with herring density and only a very weak positive relationship with sprat density. Results suggest that acoustically measured local fish density is a poor predictor of dolphin presence and abundance at the scale considered in this study. Results on cetacean abundance and distribution from this study are nevertheless potentially valuable to inform indices of biodiversity under the EU Marine Strategy Framework Directive.

Sleepless whales: Characterization of cetacean melatonin receptors and clock genes, and associated behavioral activity patterns.

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Circadian rhythms, ranging from biochemical processes to behavioral responses, are ubiquitous in nature and are generated by a biological clock at the cellular/molecular level. The core oscillator operating this clock is composed of an autoregulatory transcription-translation feedback loop controlled by a set of clock genes that are entrained to day and night rhythms by solar irradiation. Although most mammals possess well defined diel behavioral rhythms, baleen whales are believed to be arrhythmic with regards to behavioral activity. To elucidate the underlying molecular mechanisms that would result in arrhythmic behavior, the melatonin receptors, MTNR1A and MTNR1B, the enzymes controlling the synthesis of melatonin (*Aanat* and *Asmt*), as well as the clock genes (*Clock*, *Bmal*, *Per1 & 2*, *Cry1 & 2*, and *Rev-Erbα & β*), were examined for function by analyzing six high coverage cetacean genomes: minke whale (*Balaenoptera acutorostrata*), sperm whale (*Physeter macrocephalus*), baiji dolphin (*Lipotes vexillifer*), finless porpoise (*Neophocaena phocaenoides*), beluga whale (*Delphinapterus leucas*), and orca (*Orcinus orca*). Results from this study show the lack of MTNR1A genes in all cetaceans examined, as well as considerable mutations in the MTNR1B, *Aanat* and *Asmt* genes, suggesting cetaceans lack the biochemical processes to synthesize and bind melatonin. The eight clock genes examined appear to be functional in most species, however, three single point mutations were identified in three different genes from three different species suggesting pseudogenization. We have reviewed previously published telemetric data for a variety of behaviors including foraging, resting, traveling and exploring that reported behavioral activities for more than 24 hrs. Although there were clear incidents supporting arrhythmic behaviors, the majority of behaviors were defined as being rhythmic. However, when these individual behaviors were incorporated together into an artificial 24 hour day, the results strongly suggest that the animals are active throughout a 24 hour period with intermittent sleep bouts.

Recent advances and challenges in marine mammal impact assessments for underwater noise

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Growth in the blue economy is driving increases in noise-generating activity, notably the construction

of offshore wind farms and other marine infrastructure, seismic surveying of oil and gas deposits, and shipping. Policymakers and regulators are increasingly aware of the impacts of underwater noise on marine mammals, and require clear and up-to-date scientific guidance to assess the risk of proposed activities, particularly in relation to species and habitats with statutory protections.

Here, we review recent developments in risk assessment of underwater noise pollution which we have encountered through our roles as scientific advisors to UK Government and regulatory bodies in England and Wales, and as technical consultants producing environmental impact assessments (EIAs) for developers in other jurisdictions.

We use case studies to assess the implications for EIA of updated noise exposure criteria for hearing impairment in marine mammals in relation to previous guidance. Since both auditory frequency weightings and noise exposure thresholds determine the extent of effect zones produced for permanent and temporary threshold shift (PTS and TTS), it is necessary to run modelling scenarios to understand the interaction of these frequency-dependent factors with source spectrum and sound propagation characteristics. Based on typical EIA scenarios, we use noise modelling techniques to demonstrate the relative differences in risk assessment yielded by the updated guidance for each of the five marine mammal functional hearing groups.

Assumptions of animal behaviour are also instrumental in determining PTS/TTS effect zones, and the parameters used to describe fleeing responses strongly affect the assessment outcome. Similarly, the application of noise abatement technologies can greatly influence the assessment of risk, although their use is often not included in assessments. We explore the influence of these factors on EIA for noise-generating activities, and review the scope for future advances and developments in risk assessment as our scientific understanding evolves.

Conflicting physiological adaptations between thermoregulation and diving energetics in elephant seals

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Deep-diving marine mammals face significant thermoregulatory challenges living in a highly thermally-conductive environment and encountering steep vertical temperature gradients. They are well-insulated to conserve heat, but dissipating heat may result in a conflict between the dive response and thermoregulation as both are affected by the regulation of peripheral blood flow. To coordinate these physiological adaptations, marine mammals may have a temporally-delayed thermoregulatory response during normal diving behavior. We assessed this hypothesis by equipping freely-diving juvenile northern elephant seals (*Mirounga angustirostris*; n=2) with custom-built heat flux (HF) biologgers over short at-sea trips. Skin temperature and HF measurements from two sensors were analyzed relative to diving behavior and water temperature. While skin temperature at both locations remained within 2.5°C of water temperature, significantly greater skin temperatures and heat loss at the axilla ($p<0.0001$) suggest this region serves more as a thermal window than the flank. HF patterns revealed heat is lost throughout most of the dive at an average rate of 74.4 W/m^2, and a transition to heat gain occurs at the end of the ascent phase near the thermocline, and then peaks at the surface with an average magnitude of 131.2 W/m^2. Average HF throughout the dive was independent of dive depth or duration; however, average heat gain during the post-dive interval was positively correlated with both dive depth and duration ($p<0.001$). These results support our hypothesis and suggest peripheral cooling prevents conflict with the dive response and may be partially compensated by post-dive heat gain in shallow, warmer waters particularly for longer dives. Work is continuing using modified HF biologgers that incorporate additional measurements to explore the mechanisms underlying these thermoregulatory responses. This will lay the foundation for comparing the plasticity of physiological adaptations during normal and disturbed diving behavior to better predict and mitigate the effects of anthropogenic disturbances.

In the path of floodwaters: Short-term effects of Hurricane Harvey on bottlenose dolphins (Tursiops truncatus) in upper Galveston Bay, Texas.

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In late August 2017, Hurricane Harvey's historic rainfall over Southeast Texas inundated the Galveston Bay estuary system with a volume of freshwater equal to the average annual inflow. As a result, salinity levels in the bay declined rapidly from an average of 14ppt to <1ppt, altering aquatic habitat in the weeks following the storm. Long-term photo-identification monitoring efforts since 2013 provided an opportunity to evaluate the effects of this extreme flood event on the bottlenose dolphins *(Tursiops truncatus*) inhabiting upper Galveston Bay. We evaluated dolphin encounter rates for the months preceding and following Hurricane Harvey, as well as visual prevalence and extent of dolphin skin lesions, typically presenting as ulcerated or degraded epidermis. Encounter rates of dolphins in the study area decreased from 1.09 dolphins per linear kilometer (d/km) in August 2017 before the storm to 0.29 d/km in September 2017 (compared to September 2016 encounter rates of 0.91 d/km). While most dolphins evacuated the upper portion of the bay, many remaining individuals shifted habitats from shallow open bay to ship channels where salinity levels were higher at depth. Encounter rates increased when surface salinity rose to 10-11ppt after almost 8 weeks. Skin lesions significantly increased in both prevalence within the population and extent of body coverage during the freshwater flood event. As salinity recovered, the extent of lesions decreased, while the prevalence of lesions remained elevated over pre-storm levels at least four months after Harvey. This study provides an important step toward understanding the effects of flood events on estuarine dolphin populations in the Gulf of Mexico. With the predicted increase in the frequency of intense storms due to climate change and planned storm management infrastructure projects in Galveston Bay, continued research is imperative to manage the availability of habitats where dolphins can find refuge during these events.

Identification of potential signature whistles from free-ranging common dolphins (Delphinus delphis) in South Africa.

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Conveying identity is important for social animals to maintain individually based relationships. Communication of identity information relies on both signal encoding and perception. Several delphinid species use individually distinctive signature whistles to transmit identity information, best described for the common bottlenose dolphin (*Tursiops truncatus*). In this study, we investigate signature whistle use in wild common dolphins (*Delphinus delphis*). Acoustic recordings were analysed from 11 encounters from three locations in South Africa (Hout Bay, False Bay, and Plettenberg Bay) between 2009 and 2017. The frequency contours of whistles were visually categorised, with 29 signature whistle types (SWTs) identified through contour categorisation and a bout analysis approach developed specifically to identify signature whistles in bottlenose dolphins (SIGID). Categorisation verification was conducted using an unsupervised neural network (ARTwarp) at both a 91% and 96% vigilance parameter. For this, individual SWTs were analysed type by type and then in a 'global' analysis whereby all 497 whistle contours were categorised simultaneously. Overall the analysis demonstrated high stereotypy in the whistle structure and temporal production of common dolphins, consistent with signature whistle use. We suggest that individual identity information may be encoded in these whistle contours. However, the large group sizes and high degree of vocal activity characteristic of this dolphin species generate a cluttered acoustic environment with high potential for masking from con-specific vocalisations. Therefore, further investigation into the mechanisms of identity perception in such acoustically cluttered environments is required to demonstrate the function of these stereotyped whistle types in common dolphins.

Summary of recorded cetacean stranding in Krasnodar region of Russian Federation in 2018 and 2019.

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Stranding of cetaceans on the Black Sea Coast in Russian Federation are being monitored by different scientific organisations. However in the literature there are mainly publications about strandings on the territory of the Crimea. As for Krasnodar region there was little information about the numbers of stranded animals of all three species of cetaceans living in the Black Sea. With many strandings happening around Krasnodar region it became necessary to record the rate and patterns of stranding, which led to organization of stranding network to perform systematic work on recording of stranded cetaceans and determination of possible causes of death in 2018 - 2019.

The monitoring of strandings was carried out on 450+ kilometers of the Black Sea coast (from Sochi

(border with Abkhazia) to Taman Bay) during 1 year (April of 2018 - April of 2019). In addition, several strandings that took place in Abkhazia were recorded. Cetacean stranding detection methods included: 1) Social media 2) Mobile Hotline; 3) Coastal patrols; 4) Messages from the current network of volunteer-observers; 5) Obtaining information from the State Supervisory Services; 6) Receiving data from travel companies.

As a result of research we recorded 196 deceased cetaceans on the coast of Black Sea. Highest number of strandings was recorded in April of 2019 with 67 individuals. According to the data we collected the following numbers of each species were recorded:

Harbour porpoise (Phocoena phocoena) - 93;

Common dolphin (Delphinus delphis) - 49;

Black Sea Bottlenose dolphin (Tursiops truncatus) - 15;

unidentified species - 39.

14% of all deceased cetaceans had clear signs of entanglement in fishing gear. Majority of carcasses were in advanced decomposition stages, therefore no signs of fishing entanglement were present.

The development of stranding monitoring network led to more accurate data on numbers of stranded cetaceans in Krasnodar region.

Cultural tradition in Baird's beaked whales (Berardius bairdii)

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Socially transmitted behavioral patterns – cultural traditions – were observed in many whale species from large baleen whales to small dolphins. However, no traditions have been described so far in beaked whales – elusive and poorly studied group of toothed whales. We studied Baird's beaked whales in the coastal waters of the Commander Islands (Russia) for eleven years (2008-2018). Among 184 Baird's beaked whales identified in the Commander Islands, about one third came to the study area regularly year after year, while other animals were registered only once over the study period. Baird's beaked whales are normally sighted in deep-water regions, but 60 out of 446 encounters in our study area occurred in rather shallow waters (100-300 m). All of the shallow-water encounters were represented by 'resident' animals that have been regularly sighted in the Commander Islands, while 'transient' whales have never been observed in shallow waters. About half of the shallow-water encounters involved groups consisting of females with calves. We hypothesize that 'resident' animals familiar with the area are targeting some specific prey (for example, Pacific cod, Pacific halibut or rougheye rockfish) which is abundant on the shelf of the Commander Islands at depths of 50-350 m. 'Transient' whales unfamiliar with the area follow the typical foraging behavior for this species: they hunt prey along the shelf slope at depth (typically 700-1800 m). The observed difference in behavioral patterns between 'resident' and 'transient' animals suggests that hunting in the shallow waters is a cultural tradition of the local Baird's beaked whale community, maintained through the social transmission of knowledge on the prey distribution in the coastal waters of the Commander Islands. Shallow-water foraging can be especially beneficial for females with calves because it is less energy consuming. The study was supported by the RFBR grant 18-04-00462.

Application of molecular techniques to the diagnosis of Cetacean Morbillivirus and Herpesvirus in beaked whales stranded in the Canary Islands.

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The aim of this study was to perform an *evaluation* of population *health* among beaked whales stranded in the Canary Islands, focused on *Cetacean Morbillivirus* (CeMV) and *Herpesvirus* (HV). A total of 54 beaked whales, stranded between 1999 and 2017, were analyzed, including 34 Cuvier's beaked whales (*Ziphius cavirostris*) and 20 specimens belonging to the *Mesoplodon* genus. The analyzed samples included skin, lung, liver, intestine, mesenteric or mediastinal lymph node, kidney, spleen and brain. A real-time polymerase chain reaction (PCR) was carried out for CeMV, with primers designed from a partial consensus sequence of the phosphoprotein gene obtained from a dolphin morbillivirus (DMV) detected in a bottlenose dolphin (*Tursiops truncatus*), a pilot whale morbillivirus detected in a short-finned pilot whale (*Globicephala macrorhynchus*) and a CeMV detected in a guiana dolphin (*Sotalia guianensis*), amplifying a product of about 150 base pairs (bp). A conventional nested PCR was performed for HV, amplifying a fragment of the DNA polymerase gene of the Herpesviridae family of about 200 bp. Only 1/34 animal (2.9%) was positive for DMV in the *Ziphius cavirostris* group. The sequence showed a 100% homology with a sequence detected in a striped dolphin (*Stenella coeruleoalba*) stranded in Portugal in 2007 (GenBank Acc. No.: KP835995); and 4/34 animals (11.76%) were positive for HV, with sequences showing the highest homology with an alphaherpesvirus 1 sequence detected in a Cuvier's beaked whale stranded in the Mediterranean in 2012 (GenBank Acc. No.: KP995682). *Mesoplodon* genus was not positive for CeMV, while 3/20 animals (15%) were positive for HV, with sequences showing the highest homology with an alphaherpesvirus detected in a Blainville's beaked stranded in the Canary Islands in 2004 (GenBank Acc. No.: JN863234). This study increases the knowledge about viruses affecting beaked whales, being primary pathogens causing diseases, and even death, in some cases.

Presence of rake marks in common bottlenose dolphins (Tursiops truncatus) across age and sex classes: What's normal?

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Common bottlenose dolphins live in a fission-fusion society with a complex social structure that changes across their lifespan. Rake marks (i.e., epidermal scratches delivered by conspecific's teeth) are obvious, long-lasting indicators of social interactions and can vary in severity from superficial to deep. The presence or absence of rake marks is one way of assessing the degree and kind of interactions in which individuals engage, but little is known as to what constitutes a normal number of rakes or whether differences should be expected between age and sex classes. This study seeks to describe normal rake coverage in the long-term resident Sarasota Bay bottlenose dolphin community measured during health assessments. The entire bodies of 24 temporarily-restrained dolphins (13 male, 11 female, ages 2-33 yrs) were examined and their rakes mapped, counted, and categorized by depth. Adult males had the most rakes (M=32.1, SD=14.9), followed by subadult males (M=20.5, SD=3.5), subadult females (M=11.5, SD=3.5), adult females (M=8.2, SD=6.6), male calves (M=8.0, SD=1.0), and female calves (M=3.3, SD=2.8). Males had significantly more rakes than females (p=0.0004), and adult males had more rakes than younger males (p=0.047). Overall, 7.77% of the rakes were categorized as "deep" (i.e., dermis visible), and this was similar across sexes. Information on normal rake coverage for all age and sex classes of free-ranging dolphins provides an indicator of the quality of recent social engagements of individuals observed in the ocean, stranded dolphins, and dolphins living in aquaria.

Ringed seals at the edge of their geographic range undergo acute seasonal and annual blubber depth changes compared to core populations.

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Ecological theory suggests that demographic responses by populations to environmental change vary depending on whether they occur centrally or peripherally within a species geographic range. Here, we test this prediction by assessing ringed seal (*Pusa hispida*) body condition response to long-term and seasonal environmental changes. We compare a population located at high latitudes in core species range (central) with a population located at the southern extremity of the species range (peripheral). First, we examined long-term patterns in sea ice and a climatic index, key environmental variables shown to influence ringed seal demography. For the central region, ice conditions shifted in the early 1990s to increasingly warmer conditions; whereas a later shift in 1999 occurred in the peripheral region. We chose to test for seasonal and annual changes in seal blubber depth over the recent environmental period since the shift (after 1990 and 1999 in the central region and peripheral region, respectively). Although both central and peripheral seals responded to similar environmental changes associated with initiation of spring, duration of open water, and the North Atlantic Oscillation; only peripheral seals varied in blubber depth with season and year. Central seals displayed minimal changes in body condition by season and year while peripheral seals varied considerably with season displaying a 20-60% amplitude change in body fat with a phase shift to earlier initiation of fat accumulation and loss relative to central seals. Lack of variation in central seal condition by season and year may indicate an evolved match between species adaptations and environmental perturbations. Knowing how different populations respond to environmental change depending on geographic location within a species range can assist in managing population specific responses to climate warming.

Dermatophitosis by Trichophyton spp. causing generalized skin lesions in a bottlenose dolphin (Tursiops truncatus): First report in a free-ranging cetacean.

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A male calf bottlenose dolphin (*Tursiops truncatus*) stranded alive in Tarifa (Cádiz, Spain). After several attempts of reintroduction, the animal was transported to a rehabilitation centre (Regional Government of Andalusian). It was still dependent on the mother's milk and its body condition was progressively declining. After being under human care for eleven days, the animal finally died. A complete standardized necropsy was performed and tissue samples were collected and fixed in 10% neutral buffered formalin for histopathological analysis. Grossly, multiple rounds to oval, sometimes rectangular, irregular, slightly raised and discolored skin lesions were diffusely distributed from the head to the caudal peduncle of the specimen. A peripherical and central depression of the skin was a characteristic feature of the lesions. Histologically, a regular hyperplasia was observed characterized by the presence of mitotic figures at the basal layer (stratum germinativum). A slight interstitial edema was present at the mid-superficial layers of the stratum spinosum and a marked hyperkeratosis with abundant death cells was present at the upper layer (stratum externum) of the epidermis intermixed with some tortuous empty or slightly basophilic tracks. The PAS and the Grocott stains revealed the presence of abundant hyphae-like structures within the hyperqueratotic layers. These hyphae positively reacted with an anti-*Trichophyton* antibody, and it came out negative with a panel of other primary reagents against different fungi. Dermatophytes are fungi that grow on the outermost layers of the skin of animals, including muco-cutaneous membranes, genitalia, external ears, as well as dead skin or hair. Infections caused by dermatophytes, seem to be rare in marine mammals, and therefore also in cetaceans. Up to date a single case of *Trichophyton* spp. isolated from widespread superficial nodules on the trunk of an Atlantic bottlenose dolphin kept in captivity in Japan has been reported.

An integrated framework to assess the carrying capacity of whale-watching tourism and the case of Praia do Forte, Northeastern Brazil.

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Whale-watching has been increasing around the world and there is growing concern about its potential effects on the targeted animals. In order

to be sustainable it is important to determine its carrying capacity. Based on a literature review on sustainable whale-watching management and the concept of tourism carrying capacity, we propose an integrated framework that includes an evaluation of biological , social and economic aspects, considering the stakeholders involved and the current management capacity in place at a specific locality. The case of Praia do Forte, northeastern Brazil, is analyzed under this framework, considering tourist satisfaction and operator questionnaires, the current scientific knowledge on the targeted humpback whale population and the legislation and management measures in place. during 2015, 284 trips took place with 3,117 tourists. In the same year, 50% of tourists interviewed had their expectations fully satisfied and 96% would go whale-watching in Praia do Forte again. The activity employed a total of 39 permanent staff and an additional 14 temporary staff during the whale-watching season, of which 26 are from the local communities. All operators considered the activity financially viable and profitable for their companies and expected it to expand in future years. Three out of five operators believed there could be more boats operating in Praia do Forte. Operators also pointed out the lack of involvement or support from public authorities in the development, marketing and management of this activity as a limiting factor. The humpback whale population targeted has been recovering from exploitation at an estimated 7.4 to 15.2% annual rate and reoccupying former breeding areas along the Brazilian coast. Based on this analysis we consider that whale-watching in Praia do Forte is currently below its carrying capacity, however, we recommend limiting the activity to its current level, until more data and management capacity become available.

Veterinary pathology of stranded cetaceans in Canary Islands (06-12)

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The occurrence of disease in aquatic organisms will be probably one of the long-term consequences of climate change and environmental degradation. Cetaceans are regarded as sentinel species to monitor marine and marine-terrestrial interface ecosystems wherein humans are strictly integrated. Cetaceans are exposed to environmental stressors either anthropogenic, e.g., chemical and acoustic pollution, fisheries, maritime traffic, tourism industry, and non-anthropogenic, hereafter 'natural,' e.g., biotoxins, pathogens (bacteria, fungi, parasites, viruses). . Some of these pathogens have epizootic potential, are zoonotic or display complex pathogeneses in which biotic, e.g., genetic stock, immunologic dysfunction, and abiotic, e.g., chemical pollutants, may play a major role.

This study describes the pathologic findings and most probable causes of death (CD) of 224 cetaceans stranded along the coastline of the Canary Islands (Spain) over a 7-year period, 2006–2012. Most probable CD, grouped as pathologic categories (PCs), was identified in 208/224 (92.8%) examined animals. Within natural PCs, those associated with good nutritional status represented 70/208 (33.6%), whereas, those associated with significant loss of nutritional status represented 49/208 (23.5%). Fatal intra- and interspecific traumatic interactions were 37/208 (17.8%). Vessel collisions included 24/208 (11.5%).

Neonatal/perinatal pathology involved 13/208 (6.2%). Fatal interaction with fishing activities comprised 10/208 (4.8%). Within anthropogenic PCs, foreign body-associated pathology represented 5/208 (2.4%). A CD could not be determined in 16/208 (7.7%) cases. Natural PCs were dominated by infectious and parasitic disease processes. Herein, our results suggest that between 2006 and 2012, in the Canary Islands, direct human activity appeared responsible for 19% of cetaceans deaths, while natural pathologies accounted for 81%. These results, integrating novel findings and published reports, aid in delineating baseline knowledge on cetacean pathology and may be of value to rehabilitators, caregivers, diagnosticians and future conservation policies.

Marine habitat use by the Mediterranean monk seal population of Madeira archipelago

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The Madeira archipelago is home to one of the few surviving Mediterranean monk seal populations in the world. Information about marine habitat use, range of movements, and foraging areas for this population has never been available due to the difficulty of tagging individuals. The development of ankle bracelets and Fastloc GPS to tag monk seals at the Cabo Blanco monk seal colony opened the possibility to also tag individuals from the Madeira population. Using the same methodology, 5 bracelets equipped with GPS tags and Time Depth Recorders were deployed on 4 different individuals (3 breeding females and 1 adult male). One of the bracelets was lost and the others were recovered after deployment durations of 378, 355, 355 and 30 days. The full archive of dive behavior was available for all the deployments, resulting in 1115 monitoring days. The maximum depths recorded were 393 m for an adult male and 429 m for a breeding female, but most of the dives (82.26%) were shallow < 50 m. Only 0.39% of the dives were to depths > 200 m. We identified 4 distinct dive types: traveling, shallow and deep bottom foraging, and bottom resting. The foraging dives occurred, on average, at 26 m and 102 m. Fastloc GPS antennas suffered from heavy damage due to abrasion with stones. Consequently, only 193 and 98 days of at-sea locations were obtained for 2 deployments of breeding females. The resulting GPS locations were distributed around Desertas and Madeira main island, but inside the 200 m depth contour. This suggests that monk seal foraging habitat at this archipelago is within this shelf area, which is limited to only 743 km2. The quality of the marine environment and fisheries management in this area may play a key in the recovery and sustainability of this endangered population.

To be or not to be: The role of absences when modelling cetacean distributions.

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Ecological niche models are a key element to apply effective management and conservation decisions. However, when working with cetaceans, obtaining accurate estimates of species' niches might be challenging, due to the species motility and the environment dynamism. While the concept of presences is quite straightforward (a place where the organism has been observed), absences might strongly differ. Methodological absences are the result of bias and scarceness in the survey information and represents the most important source of uncertainty for the study of species distributions. We used a theoretical framework (20 cetacean-based virtual species with distinctive habitat preferences and encounter rates) to better understand the role of absences when modelling cetacean distributions. We simulated a real-world survey to last 4 months per year over 4 years. Occurrence data (presence/absence) for the virtual species were pooled together with a set of environmental variables, 3 modelling approaches were used: presence-only (PO), presence-background (PB) and presence-absences(PA). The overlap between the constructed models and the virtual species on the geographical and environmental space was used to measure the accuracy of the projections. In general, results showed that PB models (specifically Maxent) were more accurate. However, differences were found between specialists and generalist species. For specialists, both PA and PB produced good estimates, with some variation related with the species prevalence (suitable area occupied by the species) and dynamism. On the other hand, PA algorithms (e.g. GAMs) for the generalist species produced highly over-fitted predictions, while PB methods produced good estimates. PA tended to model the sampling effort and not the species distribution. Therefore, the prevalence and the ecological specialization of the species studied can strongly affect the results of the algorithms used. As a precautionary approach, we recommend the use of several algorithms, together with overlap metrics to obtain a metric of the predictions reliability.

Stranding records of the Guiana dolphins Sotalia guianensis (van Bénéden, 1864) in the Amazon estuary, northern coast of Brazil

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The Guiana dolphin *Sotalia guianensis* is restricted to bays, estuaries and shallow waters along the western South Atlantic and Caribbean coast, occurring in Central and South America. In the Amazon estuary (north coast of Brazil), this dolphin is one of the cetaceans most affected by incidental catches in gill nets, and consequently the most observed in strandings. This report is a preliminary approach about Guiana dolphin strandings in the Amazon estuarine regions of Marajó Island and northeast Pará State, recording between the years 2005 and 2016. We analyzed the annual frequency of strandings, and its seasonality variations based in the local rainy (December - May) and dry seasons (June - November). In addition, we estimate the age composition of 80 of the most preserved stranding specimens, by counting the Groups of Growth Layers (GLG) in teeth, to associate with the seasonal stranding pattern. During the twelve years of monitoring were recorded 608 strandings specimens: 70 females, 71 males and 467 of unknown sex. The lowest number of stranding occurs in 2016 (N=18, Mean=3±2SD), and a maximum number in 2013 (N=124, Mean=10±6SD). The stranding specimens ages ranged from one to 35 years old (Mean=12±7SD), and the more frequent ages were 2 and 10 years. The age classes from six to 18 years included 55% of the analyzed sample, containing only physically immature specimens frequently stranded in the rainy season. Changes in the strandings seasonality pattern were observed over the years. In six years, a major proportion of strandings (56 - 70%) occurred in the rainy season while in the other six years a dry season has the greater values (56 - 98%). These stranding seasonality changes and a number of immature specimens recorded are probably related to variations in the fishing activity/effort over the years in the Amazon estuary.

Using passive and active acoustics to explore spatio-temporal patterns of behaviour in coastal bottlenose dolphins and their prey

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Cyclic patterns of top predators are predicted to be related to those of their prey. However, obtaining direct evidence of predator responses to prey behaviour remains challenging. We aimed to characterise seasonal, tidal and diel patterns of behaviour in a coastal population of temperate bottlenose dolphins and compare these to the spatio-temporal variation in the occurrence and/or behaviour of their prey. We used a 2010-16 dataset from passive acoustic devices (CPODs) to characterise variation in dolphin presence at three high density inshore sites in NE Scotland. Data revealed site-specific cyclical patterns in dolphin presence, with a strong tidal effect at one but not all sites, and a strong interaction between season and diel patterns. Notably, dolphin occurrence became highly nocturnal in autumn, which we predicted was due to an influx of wintering Clupeiid prey that exhibit nocturnal vertical migrations. To test this, we conducted monthly transects through 2018 at two study sites using a Simrad echosounder and 38kHz transducer. In addition, we repeated earlier studies that used a vertical array to estimate dolphin dive depths, with the aim of exploring whether dive depths also varied seasonally and nocturnally. There was marked short-term and seasonal variation in the 3D spatial distribution of prey schools that was related to observed seasonal and diel patterns of dolphin occurrence. However, we found no evidence of tidally related changes in prey at the site that exhibited strong tidal use by dolphins; most likely because these are probably related to changes in occurrence of large migratory prey that were less likely to be detected in echosounder surveys. Our findings demonstrate the value of integrating passive and active acoustics to better characterise predator-prey relationships in these coastal environments, but also highlight the need to consider other approaches to characterise the full range of prey available.

Hematological abnormalities in stranded Guadalupe fur seals (Arctocephalus townsendi)

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Guadalupe fur seals (Arctocephalus townsendi; GFS) are endemic to the west coast of North America from Mexico to Washington State and were hunted to near extinction by the early 1900's. The population is now protected and has been increasing, however information on health is limited. A total of 78 GFS pups and yearlings that stranded alive in California between 2015 and 2018 during an Unusual Mortality Event were treated at The Marine Mammal Center (Sausalito, CA, USA). All were emaciated and the majority were considered anemic (hematocrit <35%: Hct) based on similar species blood value ranges. Anemia in stranded otariids often occurs secondary to malnutrition, trauma, parasitism or chronic disease, and usually resolves with improved nutrition and supportive care. However, progressive, severe anemia (Hct as low as 7%) occurred in five GFS with no evidence of concurrent disease during rehabilitation. Diagnostic testing varied but generally included fecal parasitology, radiography, ultrasound, and gastroscopy. Bone marrow aspirate and biopsy were performed in two cases. Infectious disease testing of (Sarcocystis, Toxoplasma, Neospora, Leptospira, Mycoplasma and Bartonella) was negative. Three animals recovered; two died: cause of anemia was not identified in any of these five cases. Trace element analysis from these five animals showed a severe decrease (10-fold or greater) in serum copper (range 0.2-1.78 to <0.02-0.16 ug/ml) with wide-ranging iron levels (42-109 to 27- 227 ug/dl) between admission and prior to release (n=3) or death (n=2). Samples from an additional 31 stranded GFS were analyzed for trace elements and 10 anemic GFS also had a large decrease in copper levels (0.52-1.45 to 0.04-0.19 ug/ml) and a similarly wide range of iron levels (30-158 to 41-195 ug/dl). Copper deficiency-associated anemia is rarely reported in humans and other species but should be considered in stranded GFS with persistent anemia where other cause is not identified.

North Pacific killer whales and climate change: Past, present and future.

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A rapid increase in global annual temperatures leads to decreasing ice cover, causing many ecosystem effects including Arctic and sub-Arctic species range shifts. Killer whales are increasing their presence in the Arctic following ice cover loss. The impact of killer whales on marine ecosystems differs dramatically depending on ecotype: 'resident' R-type killer whales feed mainly on fish, while 'transient' T-type whales feed mostly on marine mammals. We examined the distribution and genetic diversity of R- and T-type killer whales in the western North Pacific in order to gain insight into their range shifts during and after the Last Glacial Maximum (LGM) and to predict the potential effects of climate change on their range.

R-type whales prevail in the coastal waters of eastern Kamchatka, Commander and Kuril Islands and in the central Okhotsk Sea, where deep waters occur close to shore. In contrast, T-type whales dominate the coastal waters of Chukotka and Okhotsk Sea, represented by wide shallows covered with ice in winter. The diversity of the complete mitochondrial haplotypes of both R- and T-type killer whales was lower in the western North Pacific than in the Aleutian Islands and the eastern North Pacific, suggesting the founder effect. We hypothesize that during the LGM killer whales were driven from the western North Pacific by unfavorable ice conditions, and re-colonized it later. This suggests that North Pacific killer whales avoid ice-covered areas but can re-colonize them soon after the ice retreats. Habitat preferences provide an indication that range expansion in the Arctic will likely involve mostly T-type killer whales and consequently increase the predation pressure on marine mammals to a greater extent than on fish stocks. This should be considered in further studies and prediction models highlighting Arctic marine ecosystem change, which is relevant to management of marine protected areas (MPAs).

Minke whales (Balaenoptera bonaerensis) in the Antarctic Weddell Sea – Spatial and temporal patterns derived from long-term passive acoustic monitoring

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Antarctic minke whales (AMW) (*Balaenoptera bonaerensis*) occur in open as well as ice-covered waters throughout the Southern Ocean. Their low visual detectability and ice-associated habitat makes the species difficult to study using traditional visual methods. The recent identification of AMW vocalizations allows investigation of year-round spatial-temporal patterns of AMW occurrence in seasonally ice-covered areas by passive acoustic monitoring. Here we present AMW occurrence patterns based on 9 years (2008-2016) of recordings from 21 locations throughout the Atlantic sector of the Southern Ocean (Weddell Sea). Analyses were based on manual detection of daily presence of the bio-duck call, a characteristic acoustic signal attributed to AMWs.

We used generalized additive modeling (GAM) framework to investigate how vocal activity relates to month, ice conditions and recording latitude. AMWs were present from May to December at all but one recording locations, with highest presence occurring between August - November (>80% of days per month with bio-duck calls present). In general, acoustic presence of AMW in the Weddell Sea increases with local sea-ice concentration. At the southernmost recording locations, AMWs were present up to ten months of the year. This indicates at least a part of the AMW population remains in the Weddell Sea during austral winter.

We hypothesize that the bio-duck call has a function in a mating context and that the Weddell Sea may not only serve as a feeding ground for this species, but also provides a suitable breeding habitat for AMWs.

This long-term study, covering a large spatial scale, provides for the first time year-round information about AMW acoustic behavior in the Weddell Sea. These findings add new information about the AMW behavior and distribution in the Southern Ocean, providing valuable insights for management and conservation.

Risk of auditory damage and displacement from acoustic deterrent devices (ADDs) used in aquaculture

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Acoustic deterrent devices (ADDs) are used to mitigate seal depredation on finfish aquaculture sites through the emission of loud acoustic signals. On the Scottish west coast, ADDs use is widespread, and these devices are considered to be a significant and growing source of underwater noise pollution, with detections of ADD noise increasing over the last decade. Given the frequency ranges (2-40 kHz) and source levels (greater than 185 dB re 1 µPa [RMS]) reported for these devices, there is a risk that ADDs could adversely affect the behaviour and physiology of seals and cetaceans.

To understand the risks of acoustic impacts on harbour porpoise and seals, this study aimed to predict the extent of ADD noise from aquaculture sites across the west coast of Scotland. An energy flux model was used to calculate transmission loss around aquaculture sites known to be using ADDs. This model was coupled with sound source levels of ADDs to identify high noise areas which overlap with sites designated for species protection, and to predict the potential for auditory damage in marine mammals, based on the 2018 NOAA criteria.

Received levels of ADD noise were predicted to remain high (>100 dB) even at considerable distances from aquaculture sites (>20km). Predicted ranges for seals and cetaceans to incur temporary (TTS) and permanent (PTS) threshold shifts were considerable. For example, an ADD signal with a sound pressure level of 194 dB re 1 µPa (RMS) could cause PTS in harbour porpoise if they remained within 3 km of the source for 24 hours. Maps of ADD noise highlighted several areas of concern for auditory damage to porpoise and seals. This work highlights the potential for auditory damage from ADDs on the west coast of Scotland, and the possibility of noise-induced displacement leading to exclusion from biologically important habitats.

Conditioned hearing suppression in dolphins warned of impending noise

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Some species of marine mammals can learn to reduce their hearing sensitivity as a way of "self-

mitigating" an impending noise exposure. At present, however, the underlying mechanisms and the spectral and temporal properties of such conditioned hearing suppression remain poorly understood.In this study, the ability of dolphins to self-mitigate noise exposures was investigated by examining changes in auditory brainstem responses (ABRs) to tone bursts presented before, during, and after a warning sound and intense tone. Measurements were conducted with trained bottlenose dolphins under water and in air. During underwater testing, binaural ABRs were measured in two dolphins as intense tone frequency and tone burst frequency and level were systematically varied. During in-air testing, monaural ABRs from each ear were measured in two additional dolphins as the intense tone level was varied. Results showed frequency-specific attenuation of ABRs after pairing the warning and more intense tones, with ABR threshold shifts (reduction in hearing sensitivity) as large as 40 dB. Suppression of ABRs occurred within a few seconds, and could be maintained for at least 31 s. Once the warning sound was no longer paired with the intense tone, ABRs returned towards baseline values. During in-air testing, ABRs originating in each ear were similarly attenuated when the warning/intense sounds were presented via a contact transducer located on the right lower jaw. Results indicate a neural mechanism originating at the level of the cochlea or auditory nerve, which suggests the involvement of efferent nerve projections to the cochlea. Self-mitigation of impending noise exposures may allow marine mammals to reduce noise impacts if they are warned of impending high-intensity noise; for example, by ramping up exposure levels. The potential for self-mitigation should also be considered when interpreting marine mammal temporary threshold shift data.

Using unmanned aerial vehicles (UAVs) to investigate the effect of tourism activities on cetaceans: An aerial perspective on humpback whale behavioral responses to swim-with interactions in Vava'u, Kingdom of Tonga.

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The use of Unmanned Aerial Vehicles (UAVs) is revolutionizing marine mammal research. These include Vertical Take-Off and Landing (VTOL) UAVs, which have been successfully tested for several applications, such as cetacean behavioural surveys. This study represents the first empirical assessment of the effects of in-water tourism interactions on cetacean behaviour using UAV methodology. The Kingdom of Tonga is one of the few countries permitting "swim-with-whales" activities. The Vava'u archipelago, in particular, is one of the most important breeding and calving ground for Oceania humpback whales (*Megaptera novaeangliae*), where the local swim-with-whales industry focuses primarily on mother-calf pairs. Research on swim-with-cetaceans tourism indicates that these kinds of interactions affect cetacean behaviour and can lead to negative effects on the animals involved.

Eighty-two VTOL UAV surveys took place in Vava'u during the 2016 and 2017 whale breeding seasons from both dedicated research and swim-with-whales platforms. Whales' behavioral state was assessed from aerial videos recorded flying at 30 m altitude and the behavioral budgets in presence and absence of swim-with-whales tourism activities were compared. Whale calves' dive time, respiration and diving rates, and the time spent at the surface without the mother were also recorded. Results indicate that in-water tourism activities significantly altered humpback whale activity budgets in Vava'u. In particular, mother-calf pairs decreased the proportion of time spent nurturing (P<0.001), while time spent travelling increased two-fold (P=0.001). Furthermore, calf's respiration rate decreased significantly and the proportion of time alone spent at the surface increased more than four-fold (P=0.001). Finally, whale agonistic displays directed towards swimmers were observed. These findings highlight how UAVs can be a valuable tool for the assessment of cetacean behavioral responses to human activities and reinforce the need for a precautionary management of swim-with-whales tourism in Tonga and other countries, where these types of interactions are permitted.

Use of MOTE systems to augment argos data collection and maximize temporal resolution of GPS locations for a narwhal tracking study in Milne Inlet, Nunavut.

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The potential effects of commercial shipping on narwhal movement along an active shipping route in Milne Inlet, Nunavut, were investigated by analyzing animal-borne tag data relative to AIS-based ship movements during the 2017 open-water season. High-resolution spatial and temporal data is required to effectively resolve fine-scale behavioural responses of narwhal relative to vessel distance. Location data was obtained from 15 narwhal outfitted with Argos satellite biologging tags (SPLASH-10 backpack tags with Fastloc GPS technology; Wildlife Computers) over a period of 33 to 94 days during the 2017 open-water season. Two Wildlife Computers MOTE installations (ground-based receiver stations) were used to augment successfully received tag transmissions in the local study area. The inclusion of MOTE data roughly doubled the data retrieved, compared to that collected by Argos satellites alone. Analysis of the realized Argos, MOTE and Fastloc data performance from 2017 allowed for an estimate of the highest potential rate of successful Fastloc GPS fixes and highest data throughput possible. When balancing data collection with data recovery, it was estimated that up to 12 successful Fastloc GPS locations may be recovered from a one-hour period. Tag programming in 2018 was modified to allow for collections of Fastloc GPS data at this maximum potential rate. Current analysis of 2017 movement data indicates that narwhal elicit behavioural responses to ships moving at distances up to 5-km, corresponding to an exposure period of approximately 30 minutes. This finding highlights the need for narwhal GPS location data with increased (sub-hourly) temporal resolution.

Utilizing next-generation sequencing to identify prey DNA in western north Atlantic grey seal (Halichoerus grypus) diet.

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Traditional studies of pinniped diets rely on analysis of hard parts, or material surviving digestion, collected from scats. However, hard parts analysis can be biased because 1) seals can consume soft parts of large prey items, excluding hard parts, 2) certain prey possess fragile otoliths or other parts which degrade easily, and 3) some prey lack identifiable hard parts. Alternative methods such as fatty acid and stable isotope analyses of pinniped tissues are limited as they frequently can only identify prey with coarse taxonomic resolution. To counter these limitations and collect novel data on USA grey seal (*Halichoerus grypus*) feeding habits, we utilized next-generation sequencing of vertebrate prey DNA from seal scat using 16S amplicons. Our overall aim was to better understand grey seal foraging ecology amidst rising social, political, economic, and ecological controversies with increased seal abundance in the Gulf of Maine. We collected seal scat (N = 82) from two breeding colonies in Massachusetts, USA, and assigned seal sex to scat samples using a revised PCR assay. We detected 27 prey groups, 21 of which resolved to species level. Sand lance (*Ammodytes* spp.) was the most frequently consumed prey group (N = 70/82, 85.4%), consistent with previous studies, but Atlantic menhaden (*Brevoortia tyrannus*), the second most frequently consumed species (N = 32/82, 39.0%), was not previously documented in USA grey seal diets. We found site effects on prey alpha and beta diversity, and the presence of several prey groups, whereas effects of seal sex were important only in the occurrence of one prey group (Rajidae). Our results indicate a metabarcoding approach to deciphering seal food habits can yield important new ecological insights, but traditional analyses of hard parts from pinniped scats does not underestimate consumption of species (*e.g.*, *Gadus morhua*, *Salmo salar*) that are particularly economically important in this system.

Dammed to extinction? The precarious status of Southern Resident Killer Whales.

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As an 11-year-old with a keen eye to the planet's future, I have become involved in a flagship environmental issue for the region in which I live: Southern Resident killer whales (SRKW, *Orcinus orca*). Here, I and my collaborators review the status of this endangered population. The current estimate of abundance for SRKW is 75 animals in 3 pods, down from 98 in 1995. Reproduction is low, with only 6 calves born since 2015. Neonatal survival is also low, with approximately 70% of all calves dying in their first year. In addition, recent aerial photogrammetric images have shown that the body condition of some individuals is poor and indicative of nutritional stress. Various factors have been invoked as explanations for the decline in SRKW, including pollution, noise, harassment from whale watching vessels, and insufficient prey. Of these, the lack of prey is widely regarded as the principal factor affecting recovery. SRKW preferentially target

fat-rich Chinook salmon, the abundance of which has declined, in large part because of anthropogenic degradation of habitat. In Puget Sound, only 22 of at least 37 historic Chinook populations remain. The remaining wild Chinook salmon are at 10% of their historic numbers. The single most effective conservation action to assist SRKW would be breaching of four dams on the Snake River to restore free passage of spawning salmon; yet despite broad agreement on the importance of this, it remains seemingly politically intractable. Considerable funding has been proposed by the Governor of Washington State for SRKW recovery, but unless salmon populations are restored, SRKW will likely continue to decline.

Abundance and terrestrial habitat preferences of the Guadalupe fur seal (Arctocephalus philippii townsendi) at Isla Guadalupe, México

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Guadalupe Island has the largest colony of Guadalupe fur seals (*Arctocephalus philippii townsendi*), located 240 km off the western coast of the Baja California Peninsula, in the northeastern Pacific Ocean. During the 19th century, the Guadalupe fur seal was hunted intensely, causing a severe population decline. It is currently protected in Mexico. Populations have been monitored occasionally since the 1970s and their numbers have increased. All counts have been performed from boat or on land, and no aerial count for this taxon has been reported. In this work, the population abundance of the fur seal colony on Guadalupe Island was estimated through a correction function for the population estimates, by comparing boat counts and the simultaneous taking of images from an UAV (Unmanned Aerial Vehicle). A total of 29,972 organisms were counted in photographs taken from the UAV, while observers from the boat counted 11.4% less. Aerial monitoring was significantly more efficient than boat monitoring for the total count of organisms ($p<0.05$); however, detectability by categories is not affected by the increase in the number of organisms ($p>0.05$). In addition, observations were made from land on three beaches south of the island to determine terrestrial habitat preferences during the day, both by categories and by substrates. The response of the population density (individuals km^{-2}) to the daytime environmental temperature was inferred by categories and substrate. The model suggests that tolerance to the increase in atmospheric temperature, and therefore the need to enter water for thermoregulation, varies according to the age / sex category. The density of pups, females and subadult males on land decreases faster with the increase in temperature, while that of adult males is maintained at slightly higher temperatures. No preferences were found for any type of substrate in relation to the increase in temperature.

Small-scale patterns of distribution and ecotoxicological features in bottlenose dolphins (Tursiops truncatus) in the southern Gulf of Mexico

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The Flora and Fauna Protection Area Laguna de Términos in Campeche, Mexico, has great ecological importance due to its biotic diversity, as well as being the most important area for bottlenose dolphins (*Tursiops truncatus*) in the southern Gulf of Mexico. However, this area has environmental issues, among them, the extraction of hydrocarbons, urbanization and agricultural activities that bring on the presence of pesticides in water, sediments and species of this coastal lagoon. The aim of this study was to identify the distribution zones and critical habitats for dolphins using ethological variables, delimit their home range using telemetry tracking in six adult specimens and finally, describe the spatial relationship between the dolphins and the presence of organochlorine pesticides, (mainly DDT and chlordane) in sediments and blubber of the dolphins tracked by telemetry. The results show three important sites for feeding of this species based on ethological records, as well as differences in the pollutants profiles of the six tracked specimens, such differences match with the spatial pattern of these compounds in sediments within the lagoon. These are the first results that combine data on patterns of marine mammal distribution and toxicology in the southern Gulf of Mexico and suggest that the distribution patterns of dolphins affect the concentrations of organochlorine pesticides on blubber on a small scale, these differences are usually found in populations that are located hundreds of kilometers.

Increase in large whale entanglements in 2018 in the Pacific northwest reflect improved reporting and changes in whale occurrence

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Entanglements are one of the leading human-caused mortality risks to large whales. Off California, entanglement reports to the entanglement network increased dramatically around 2015, resulting in considerable management attention to this issue. A similar increase did not occur in the Pacific Northwest (Washington and Oregon), an area where there are generally fewer reports, until 2018 when the network received 19 credible reports (15 confirmed), with evidence of additional unreported large whale entanglements. This was a marked increase over previous years, in which the number of entanglement reports had always been under 10. Of these entanglements in the Pacific Northwest in 2018, humpbacks were the most commonly reported (n=12), followed by gray whales (n=6). Here, we examine potential causes for this increase, including heightened public awareness, dedicated survey effort, and changes in whale occurrence. From 2016 to 2018, we increased education and outreach efforts with an emphasis on timely reporting and documentation engaged local fisheries, management and the public. Research survey effort that directly resulted in some 2018 reports was also higher in 2018 than in previous years, due to a combination of NOAA ship surveys and small boat effort. Humpback whale numbers have also increased throughout the Pacific Northwest with an expansion of distribution into the Salish Sea and evidence of whales remaining for longer periods. In 2018, several hundred humpback whales were documented in the Strait of Juan de Fuca coincident with a gillnet fishery in that area. For gray whales, 2018 represented a year with increased sightings of emaciated animals lingering in areas of high fishing activity as well. We propose that the increase entanglement reports in 2018 represent a combination of better reporting for this region as well as shifts in whale occurrence bringing them into greater contact with fishing activities.

Harbour seals and ship noise: Quantifying the potential for masking of mating calls in Kattegat, the Baltic Sea, by acoustic modelling.

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Underwater mating calls of harbour seals overlap in frequency with noise from ships and are thus prone to masking by the noise. The potential masking can be quantified by the excess level, which is the difference between total and natural ambient noise. The excess level is linked to the range reduction factor, which expresses the relative decrease in maximum communication range. An excess level of 20 dB translates – all else being equal – into a decrease in maximum communication range of 90%, under the simple assumption that communication signals propagate with a spherical spreading loss without absorption. A decrease by 90% or more is likely to affect mating behaviour, if it occurs for substantial parts of the breeding season. Therefore, excess level and thus potential for masking of seal calls, was modelled for the 25 major haul-out sites in Kattegat.

Natural ambient noise and ship noise was modelled independently by the acoustic propagation platform Quonops. Natural ambient noise was modelled on wind and wave statistics for July 2018 and ship noise based on AIS positions obtained for the same period. Results showed that 5% of the breeding site area (assumed within a 5 km radius around each site) was exposed to an excess level of 20 dB or more for 50% of the time. This corresponds to 5% of the population exposed above 20 dB for 25% of the time, if animal abundance is taken into account. Largest potential impact was on the sites close to both deep water and shipping lanes.

The suggested masking index has considerable potential as a simple, yet intuitive risk indicator in impact assessment of low frequency ship noise on aquatic animals, as it expresses the magnitude of the overlap (in time and space) between the ship noise and the animals.

Islands in the stream: Movement patterns of satellite-tagged pilot whales in the south Atlantic bight.

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To improve our understanding of the spatial ecology of short-finned pilot whales (*Globicephala macrorhynchus*) in the western North Atlantic, we deployed eight satellite-linked depth-transmitting tags off Jacksonville, Florida in June 2016 and November 2018. Tags transmitted up to 47 days (mean=32±11). Location data were processed with the Douglas Argos-filter to remove unrealistic positions. All tagged individuals exhibited a distinctive, repeated cyclical pattern of movement. Individuals followed the Gulf Stream north over the Blake Plateau, then moved east out of the Gulf Stream and returned south, before repeating the cycle. This pattern differs considerably from that observed in short-finned pilot whales tagged off Cape Hatteras, North Carolina (n=54), most of which demonstrate a strong affinity for the continental shelf break, including the region's canyons. However, two short-finned pilot whales tagged off Cape Hatteras in 2017 moved into the South Atlantic Bight (SAB) and exhibited movement patterns similar to those tagged off Florida. Hierarchical switching state-space models indicate that the whales tagged off Florida exhibited a low proportion of area-restricted search over the Blake Plateau (individual mean=0.23), but it is possible that the whales were foraging as they were being passively advected by the strong northward flow of the Gulf Stream. The mean depth of dives across individuals was 357m, over a mean depth at model-predicted locations of 745m, suggesting that whales were foraging in the mesopelagic realm. Telemetry tracks and photographic matches of well-marked individuals demonstrate that pilot whales in the SAB move to several adjacent areas, including North Carolina and the Bahamas, but individuals in the SAB appear to respond to the unique set of environmental features in the region. Taken as a whole, our findings indicate that short-finned pilot whales are adept at matching their foraging strategies to their local environments in the western North Atlantic.

Discharge water effects study consumed by the inhabited dwellings in ecosystem systems from the Mediterranean area, within the circular economy and climate change circle.

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This research work connects different Global Objectives of Sustainable Development, SDGs (United Nations, 2018):

- Nº.6 Clean water and sanitation.
- Nº 9 Industry, innovation and infrastructure.
- Nº11 Sustainable cities and communities.
- Nº14 Life below water.
- Nº17 Alliance to achieve the objectives.

Water is a scarce resource essential for shared life among all the living beings that inhabit it, we must work for its conservation; overpopulation, climate change and poor management of resources have a negative impact on water and ecosystem services linked to it, this affects the economy of the country. Water resources should be included in the management policies of the countries as an added value of the circular economy of these, currently it's not considered.

This work analyzes the water cycle in a house and its effects in the ecosystemics systems from the mediterranean area using a simulation program developed by PolyhedraTech, improving it the habitants from the inhabited nuclei can decide which are the best strategies to improve their use of clean water, taking into account its effects in the circular economy, minimizing the impacts on ecosystem services and, finally, acting as a knowledge brokerage between the different actors and society to advance in the reduction of human impact in the environment

There are several actors from different groups with converging concerns in this aspect, but projects that work in a transdisciplinary way have rarely been articulated; this work links architects, biologist and enginers with a same purpose, to minimize our effects in the ecosystemics systems and to optimize the water consumption.

The evolutionary history of the porpoise family across the speciation continuum through the lens of a comparative genomic approach: Putting conservation issues into an evolutionary framework.

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The porpoise family (Phocoenidae) has seven species that inhabit mostly temperate waters and display a textbook example of anti-tropical distribution. Their evolutionary history remained poorly known, and some species face major conservation issues (e.g., critically endangered vaquita and Yangzte finless porpoises). Here, we used a comparative genomic approach to reconstruct the evolutionary history of porpoises across the entire speciation continuum, from the intraspecific level to species divergence in relation to past climatic changes. We assembled the mitochondrial genomes and resequenced at low coverage the entire nuclear genome of 63 porpoises. Phylogenetic reconstructions suggest that, like other toothed whales, porpoises radiated during the late Miocene-Pliocene but their current intraspecific subdivisions were shaped by environmental variations during the Quaternary Glaciations. We highlighted a parallel evolution in both hemispheres associated with symmetric adaptations to different environments (coastal *versus* pelagic) exhibiting convergent patterns of coloration and genetic diversity. This result suggests that the mechanism driving diversification of the well-known species of the Northern Hemisphere may apply also to the poorly-known southern species. In contrast to previous results, our results showed that spectacled and Burmeister's porpoises share a more recent common ancestor than with the vaquita. The vaquita diverged from southern species during the Pliocene but has low diversity, possibly due to long-term small population size, population bottleneck(s), or small founding population in the Gulf of California. We also observed divergent lineages within Dall's, spectacled and North Pacific harbor porpoises, suggesting a richer evolutionary history than previously thought. Genetic inferences of demographic trends from mitochondrial and nuclear genomes for each species and sub-species shed light on the dynamics of population size fluctuations and subdivisions. These results provide a new perspective on the divergence, adaptation and speciation processes of the porpoises. We will discuss how this knowledge can provide an evolutionary context for their conservation.

Blubber stratification of Tursiops australis and implications for using remote biopsies

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Remote blubber biopsies can provide vital information on the life history, genetics, health biomarkers, toxicant levels, and diet of free ranging marine mammals in a minimally invasive manner. However, for a number of marine mammals the blubber layer does not have uniform composition with the level of stratification differing between species. Knowledge of any stratification that exists within a study species is crucial in the interpretation of blubber biopsy analysis. *Tursiops australis* is a newly described dolphin species, with two genetically distinct and isolated populations in Victoria, Australia. Due to the recent description in 2011, limited research has been undertaken on this species, however stable isotope analysis suggests the diet of these two populations differ. We identify the degree of blubber fatty acid stratification in the newly described *T. australis*. Whole blubber layer samples have been collected from stranded individuals, sub sampled into vertical layers and fatty acid methyl ester (FAME) analysis conducted to determine the level of stratification. This

provides the base knowledge of fatty acid distribution within the species and provides context to the use biopsies of free ranging individuals to assess the diet within each population.

Global dataset of killer whale genomes reveal a complex history of recurrent admixture and vicariance.

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Reconstruction of the demographic and evolutionary history of populations assuming a consensus tree-like relationship can mask more complex scenarios, which are prevalent in nature. An emerging genomic toolset, which has been most comprehensively harnessed in the reconstruction of human evolutionary history, enables molecular ecologists to elucidate complex population histories. Killer whales have limited extrinsic barriers to dispersal and have radiated globally, and are therefore a good candidate model for the application of such tools. Here, we analyse a global dataset of killer whale genomes in a rare attempt to elucidate global population structure in a non-human species. We identify a pattern of genetic homogenisation at lower latitudes and the greatest differentiation at high latitudes, even between currently sympatric lineages. The processes underlying the major axis of structure include high drift at the edge of species' range, likely associated with founder effects and allelic surfing during post-glacial range expansion. Divergence between Antarctic and non-Antarctic lineages is further driven by ancestry segments with up to four-fold older coalescence time than the genome-wide average; relicts of a previous vicariance during an earlier glacial cycle. Our study further underpins that episodic gene flow is ubiquitous in natural populations, and can occur across great distances and after substantial periods of isolation between populations. Thus, understanding the evolutionary history of a species requires comprehensive geographic sampling and genome-wide data to sample the variation in ancestry within individuals.

Leopard seal migration phenology responds to long-term variation in sea ice extent

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The phenology of migration is poorly understood in pinnipeds with large distribution range and relatively low abundance such as the leopard seal. Yet, it is important to understand how long term environmental variation and change is affecting their populations, local communities, and the wider ecosystem. In the Scotia Sea (southwest Atlantic), migrating seals reach the South Georgia archipelago –over 1000 km North from the pack-ice in a straight line– between February and November, and have stopover periods ranging between one day and a few months, when seals predate on locally abundant prey including other seals, seabirds, fish and crustaceans. Here, using photoidentification of 402 individuals between 2005 and 2018, we show that at Bird Island, northwest South Georgia, leopard seals migrating from the pack-ice arrive earlier, stay longer and their numbers fluctuate significantly with trends consistent with long-term variation in the sea ice environment. Our study period encompassed a temporary absence of warming in the Antarctic Peninsula and increased sea-ice extent in the Weddell Sea, which negatively correlated with the arrival of individuals and their total numbers, and positively correlated with mean stopover times. Using mark-recapture models of seasonal abundance combined with bioenergetics models and a diet analysis we found that the highest predation impact of leopard seals was on gentoo penguins (between 4 and 30% of the estimated Bird Island population), and even in years with low total numbers of seals, predation could be high because of increased stopover times. These results indicate that long-term changes in the sea-ice extent can determine the migration phenology of the leopard seal, with consequences for the prey populations they exploit at their winter destinations.

Managing anthropogenic risks to marine mammals in a changing climate: Dynamic humpback whale models to reduce entanglement risk along the U.S. West Coast.

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Along the U.S. West Coast, reports of entangled of humpback whales, *Megaptera novaeangliae*, have historically been rare, but since 2014 there has been a dramatic increase, peaking at 48 confirmed reports during 2016. Causes of this increase are complex and primarily driven by unusually persistent warm ocean conditions, which in turn affected forage species distribution, timing and intensity of fishing effort, and the distribution of foraging humpback whales. Combined with increasing humpback whale populations, these factors exacerbated the spatiotemporal overlap between whales and fixed-gear fisheries, especially the California Dungeness crab fishery. A multi-stakeholder working group tasked with reducing whale entanglements has developed an ecosystem-based process for mitigating entanglement risk before and during the Nov-July crab fishing season. The assessments are based on monitoring ocean conditions, krill and anchovy abundance, observed or predicted whale distributions, and expected fishing dynamics, taking into account the impacts of harmful algal blooms and crab market pricing. To support these risk assessments, we have developed a fine-scale (3x3 km), year-round model of humpback whale density within shelf/slope habitats where whales and the crab fishery overlap. The habitat-based model integrates 2005-2014 summer/fall shipboard line-transect survey data with bathymetry and dynamic ocean habitat variables from a data-assimilative ocean circulation model and high-resolution sea surface temperature data. Independent ecosystem and marine mammal survey data from regional ship and aerial surveys were used to validate model predictions, using quantitative metrics including area-under-the-curve and true skill statistic, as well as visual inspection of predictions vs. sightings. Bi-weekly and monthly model predictions successfully captured observed interannual and seasonal patterns in humpback whale distributions, providing a dynamic tool for assessing and mitigating whale entanglement risk. Such tools are becoming increasingly important as climate-driven changes to marine ecosystems alter the nature and

extent of human interactions with marine mammals.

Short-finned pilot whale population and social structure off Cape Hatteras, North Carolina, USA.

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Short-finned pilot whales (*Globicephala macrorhynchus*) are a highly social species which typically live in stable matrilineal groups but mate outside the group. Off Cape Hatteras, North Carolina, short-finned pilot whales are often found in large aggregations of several hundred animals. The study site runs along the continental shelf break, and previous research has indicated that this is an important foraging area for the population. In addition to its importance as foraging habitat, we used genetic data to investigate Cape Hatteras as a breeding site for short-finned pilot whales. We used RAD-sequencing to develop a panel of nuclear markers from 43 biopsy samples, including 18 pairs of individuals biopsied in the same group. After filtering, we retained 9610 high-quality single nucleotide polymorphisms for analysis. We used these markers to estimate an effective population size of 2671 (CI 2183-3440) individuals utilizing the Cape Hatteras region, with no evidence of population structure between seasons. In addition, we calculated and compared relatedness among individuals biopsied in the same or different groups. All female pairs sampled in the same group were close relatives (n = 5), while 78% of mixed-sex pairs sampled in the same group were unrelated (n = 9) as well as all male pairs biopsied together (n = 4). Female pairs were more likely to be related than male or mixed-sex pairs, but we found no evidence for sex-biased dispersal (mAIc; t = -0.936, p = 0.355), suggesting that potential male dispersal is social rather than geographical. This could indicate that males may be temporarily leaving their family units to seek out mating opportunities, and that Hatteras may be an important area for breeding as well as foraging.

Are there enough Chinook salmon for Southern Resident Killer Whales?

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Southern Resident Killer Whales show signs of poor body condition, which suggests they are unable to obtain enough of their preferred prey (Chinook salmon). However, it's unknown whether this apparent energy deficit is due to reduced abundance and quality of salmon from overfishing or environmental change, or reduced salmon accessibility by killer whales due to vessel traffic and acoustic disturbance. We sought to test the hypothesis that the availability and/or abundance of Chinook salmon is insufficient to support a healthy population of Southern Resident Killer Whales. To determine whether food limitation is driving the poor health and recovery of the Southern Residents, we conducted a co-located, fine-scale, predator-prey study to compare the availability and abundance of Chinook salmon using multi-frequency echosounders and simultaneous recordings of foraging behaviour of Southern and Northern Resident Killer Whales (a contrastingly healthy population). Knowing the vertical distribution and abundance of salmon encountered by actively foraging killer whales is critical for evaluating how prey may be limiting the foraging success of these salmon specialists. The results of our study provide important insight into the mechanisms driving the apparently poor health and recovery of Southern Resident Killer Whales and ultimately help determine how to best manage this endangered species.

Deep diving pilot whales make cheap, but powerful, echolocation clicks with extremely small volumes of air.

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Echolocating toothed whales produce powerful clicks pneumatically to detect prey in the deep sea where this long-range sensory channel makes them formidable top predators. However, air supplies for sound production shrink with depth following Boyle's law so that the available air volume for sound production at 1000 meters is 1% of the volume inhaled at the surface. This leads us to hypothesize that deep-diving whales must use very

small air volumes per echolocation click at depth and recycle the used air to facilitate continuous sensory flow in foraging dives. Here we test these hypotheses by analysing click-induced acoustic resonances in the nasal air sacs, recorded by sound and movement recording tags (DTAGs). Harnessing a fish swim bladder model to interpret these resonances, we are able to estimate the volume of air used per click as a function of depth. We then use the estimated air volume per click to infer the metabolic cost of clicking. Using 27000 clicks from 102 dives of 23 tagged pilot whales (*Globicephala macrorhynchus*) at Tenerife, we show that click production requires only 50 µL of air/click at 500 m depth increasing linearly to 100 µL at 1000 m. With such small air volumes, the metabolic cost of sound production is estimated to be on the order of 40 J per dive which is a negligible fraction (<0.1%) of the energy budget of a foraging dive. Nonetheless, step changes in the acoustic resonances indicate that whales make frequent pauses in echolocation to recycle air between nasal sacs. Thus, economic use of air and periodic recycling of very limited air volumes enable pilot whales, and likely other toothed whales, to echolocate cheaply and almost continuously throughout foraging dives providing them with a strong sensory advantage in diverse aquatic habitats.

Bearded seals adjust calling behavior to compensate for ambient noise in the Alaskan.

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In anticipation of dramatically reduced Arctic sea ice, planning is underway for a wide variety of offshore anthropogenic activities. One of the most poignant threats associated with industrialization is the increase in anthropogenic noise. This is particularly true for Arctic phocids that breed underwater and use sound to facilitate mate selection. Male bearded seals *(Erignathus barbatus)* produce elaborate underwater vocalizations believed to attract mates and defend territories; this species may be negatively impacted by increased anthropogenic noise as calls fail to reach intended receivers and energetic costs associated with increased calling effort are incurred. In order to assess species' resilience to anthropogenic perturbations, it is essential to first document behavioral responses to naturally occurring phenomena. Using multi-element time-aligned hydrophone arrays, we investigated whether bearded seals in the Alaskan Beaufort Sea employed a Lombard Effect (increased calling amplitude) in response to changes in noise levels from natural sources. Bearded seals exhibited a linear increase in call source levels associated with ambient noise; noise explained 36% of the variance in source levels. For every 1 dB increase in ambient noise, call source levels increased by 0.57 dB re 1 µPa (95% C.I. 0.4 - 0.7) indicating that seals were capable of adjusting their behavior, but did not compensate exactly for elevated noise. A broad range of ambient noise levels were observed (78 - 107 $dB_{RMS\ 10\text{-}900\ Hz}$); the highest noise levels were dominated by calling bearded seals, and to a lesser extent bowhead whale calls. While overlapping conspecific calls occurred, there was evidence that seal calls were temporally stratified. This in combination with the observed Lombard Effect may be an effective strategy to contend with periodic sounds from biological sources; however, this strategy may not be effectively applied to continuous noise sources, like vessels or marine construction.

Insulin and blubber deposition in rehabilitating harbor seal pups (Phoca vitulina).

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Seals and sea lions (pinnipeds) go through naturally occurring stages of nutrient restriction alternating with rapid weight gain. Recent work has focused on how pinnipeds manage fuel stores during periods of fasting, whereas the physiological management of weight gain has been less well-studied. Pinnipeds undergoing rehabilitation were used in a controlled setting to investigate the relationship of an important metabolic hormone, insulin, to mass gain and lipid deposition. Over two seasons, 16 rehabilitating harbor seals pups were monitored as they were fed a steady caloric intake. Plasma insulin levels, mass gain and blubber deposition were measured over the 8 week rehabilitation period. Plasma insulin levels were low, but increased significantly across the sampling period and were positively related to blubber deposition and overall mass gain. These results indicate that despite low circulating levels, insulin may play a lipogenic role in seals and that insulin sensitivity may be an important labile physiological variable affecting lipid metabolism during different life history phases. Quantifying insulin sensitivity in blubber as well as additional mediators of lipogenesis such as adiponectin during rapid lipid accumulation will further elucidate the mechanisms

by which pinnipeds modulate the relationship between insulin and lipid metabolism.

Modeling bottlenose and striped dolphins' distribution in relation to their prey's biomass in the Mediterranean Sea

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Species distribution models (SDMs) provide a useful analytical framework to study the environmental and anthropogenic factors that influence species distribution patterns, returning information that can help to define their geographical ranges and clarify which areas constitute important/sensitive habitat for their survival. For cetaceans, it has been recently shown that SDMs can be significantly improved by analyzing the species' distribution in relation to their prey, to try to account for the biotic interactions of these species with other community members on which they depend. We show here how identify areas with high probability of occurrence for two species of delphinids, one characterized by predominantly coastal habits (the bottlenose dolphin, *Tursiops truncatus*), the other pelagic (the striped dolphin, *Stenella coeruleoalba*) by modelling species' spatial location information in conjunction with their main preys. We used 1) dolphins' presence-only pooled records gathered over a 12-year period (2008-2019) by different research groups in the central Tyrrhenian Sea and systematically derived from shared photos/videos by boaters/maritime operators on social media, and 2) data on distribution and biomass of some fish and cephalopod species targeted by bottlenose and striped dolphins resulting from MEDITS survey program (International bottom trawl survey in the Mediterranean). This information has been used to model bottlenose and striped dolphins' distribution in combination with different environmental parameters, anthropogenic factors and biological cues as covariates. Log-Gaussian Cox point process models were fitted relating the dolphins' presence records to the biomass of their preys and covariates, also accounting for spatial correlation. As expected, the estimated intensity functions differed between the two species, and clear-cut relation patterns emerged especially for bottlenose dolphin. This approach could facilitate the prediction of the species' geographic distributions and the spatial identification of possible trophic interactions among species, together with the associated environmental setting, to assist management and conservation strategies.

Echo-devo: Ontogeny and evolution of the sound generating structures in dolphins (Odontoceti: Delphinida).

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The ontogeny of the main structures involved in sound generation and modulation in dolphins was investigated through the comparison of the soft nasal structures between fetal, perinatal, neonate and adult specimens of three families (Pontoporiidae, Phocoenidae and Delphinidae). Fetal samples were sectioned at 10 µ in saggital and coronal view, and stained. Existing CT and MRI-scan series were combined with new data to better represent the ontogenetic stages of the three groups. The image series were analyzed in 3D-Slicer to characterize the topographical arrangement of the tissues surrounding the nasal passage. The muscles and connective tissues surrounding the blowhole region were dissected, layer by layer, to describe and lay out the nasal soft

tissues. Morphological ontogenetic-based transformations were used to create transformational characters for phylogenetic inference. The morphogenesis of the soft nasal tissues in dolphins was remarkable for its transformation during early fetal stages: the origins of the melon and the vestibular air sac were detected between Carnegie stages C16 and F22. The three groups analyzed presented distinct formation of the nasal plug and nasal plug muscles, mainly on the loss of fat pathways (or their maintenance in Pontoporiidae) and the hyperdevelopment of the nasal plug muscles in both sides (e.g. during perinatal development of Phocoenidae) or just on the left side (e.g. during postnatal development in Delphinidae). We suggest that ancestral forms of all known delphinidans might have exhibited unique soft nasal tissue morphology capable of producing highly directional sounds as known for some narrow-band high frequency species. Thus, broad-band vocalizing delphinidans, such as most delphinids, might have evolved under heterochronic events acting on the formation of the rostrum and vestibular air sacs formation, as well as on the transformation of the branches of the melon, in turn leading to a reduced directionality of the sonar beam.

Scientific tools for estimation of bycatch impacts on marine mammal populations: An ocean modeling forum working group.

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The Ocean Modeling Forum at the University of Washington, Seattle, USA, has convened a Marine Mammal Bycatch Working Group in response to the US Marine Mammal Protection Act (US MMPA) Import Provisions, issued in 2016 by the U.S. National Oceanographic and Atmospheric Administration (NOAA). The rule requires nations that wish to continue exporting fish or fish products to the United States to adhere to bycatch standards comparable to those of the United States. The working group is compiling resources and developing scientific tools to help nations comply with the rule, with a special emphasis on data-poor fisheries. The project draws from case studies in Chile and Iceland, and uses management strategy evaluation tools to simulate how fisheries management might perform with sparse or biased data, while still meeting standards that are comparable in effectiveness to US MMPA objectives. The working group has four planned projects. The first two will address important steps in setting and applying bycatch standards: practical tools for estimating marine mammal abundance, and assessing bycatch mortality rates. The third is an online tool to synthesize data and evaluate potential management strategies. The fourth further evaluates applicability of the potential biological removal (PBR) method, the primary U.S. bycatch standard. Our objective is to provide tools and approaches to countries that aim to demonstrate standards that are comparable in effectiveness to US standards, even in cases where data quality or quantity may fall below those of many well-monitored US fisheries. Our objective in presenting the Marine Mammal Bycatch Working Group program at the World Marine Mammal Science Conference is to update marine mammal scientists and managers from >60 countries on progress made, encourage beta testing of our products, and identify opportunities to collaborate on implementation in countries where such tools are needed and our assistance may be welcomed.

Temporal trends in humpback whale abundance in Hawai‘i and response to climatic drivers

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In 2001, the non-profit Hawai‘i Marine Mammal Consortium initiated long-term monitoring with scan sampling methodology to study the relative abundance and distribution of humpback whales (*Megaptera novaeangliae*) in their Hawaiian breeding grounds. An average of 18 scan samples were collected annually (2001-2019) from a shore site overlooking Kawaihae Bay, Hawai‘iIsland, using methods to keep effort consistent. Each sample counted the number of groups and whales and measured each group’s position with a theodolite and reticle binoculars. Counts of whales and calves were analyzed using General Additive Models, including predictor variables of year, date, observational conditions, and observer, to establish a base model. Climatic indices were then added to the model, one at a time, and their contributions were evaluated using the Akaike Information Criteria. Numbers of whales and calves showed a clear increase from 2001-2010, but became variable and dropped sharply in the latter years of the study, including a precipitous 60% drop between 2013 and 2016 (coincidentally, the year of delisting Hawai‘ihumpbacks under the Endangered Species Act). The proportion of calves showed a

similar decrease, reaching a record low of 1.1% in 2016. Increased numbers of "skinny" whales in Hawai'i (2016-2019) and trends in Alaska feeding areas, suggested that prey scarcity could be a factor in the observed changes. The two best models included the Pacific Decadal Oscillation index (lagged 1.5 years) and the North Pacific Gyre Oscillation index (lagged 2.5 years). Both models indicated that whale and calf numbers increased when these climate indices reflected colder water in the North Pacific. These results suggest that oceanographic conditions during prior feeding seasons affect the number of whales on the Hawaiian breeding grounds. Continued long-term monitoring of whale populations is essential to documenting and understanding population level responses to global climate change.

Postmortem attractions: Humpback whales investigate the carcass of a killer whale depredated gray whale calf.

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Postmortem attentiveness to members of one's own species, thanatology, has been observed in various animal taxa and includes cacophonous aggregations in crows, skull fondling by elephants, and leaf dropping/adornment of the deceased by chimps. Cetaceans have been observed to care for, attend to, be aroused by, or show interest in dead or dying individuals. This includes a female southern resident killer whale who pushed or carried her deceased calf for 17 days and 100's of miles. To date, nearly all records of postmortem attentive behavior (PAB) in cetaceans are from odontocetes and directed towards members of their own species. Among the mysticetes only one observation of PAB has been recorded in the literature. This involved two adult humpbacks displaying interest in, and being sexually aroused by, a dead adult conspecific, believed to have died participating in a competitive group. Here we report on two adult humpback whales investigating and making gentle physical contact with a dead gray whale calf depredated by killer whales. This extends the list of hypersocial behaviors exhibited by humpbacks, and provides the first report of interspecies postmortem attentive behavior (iPAB) between wild species of cetaceans.

Cetacean strandings on Boa Vista Island (Republic of Cabo Verde): 2000-2019.

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Twenty-four cetacean species have been described in the waters of the Cabo Verde Islands, Northwest Africa. Boa Vista (620 km2), with a coastal perimeter of ca. 115 km, constitutes the easternmost island of the archipelago and has the largest shelf, with shallow coastal and offshore waters, and occurrence of nearshore reefs. More than 40 cetacean strandings (>800 animals) has been reported here since 2000, involving 13 species, 2 Mysticetes and 11 Odontocetes. First records of four species in Cabo Verde include: minke whale (*Balaenoptera acutorostrata*), dwarf sperm whale (*Kogia sima*), false killer whale (*Pseudorca crassidens*) and pygmy killer whale (*Feresa attenuata*). The short-finned pilot whale (*Globicephala macrorhynchus*) and the melon-headed whale (*Peponocephala electra*) account for most strandings events (ca. 31% and 19%, respectively). The mean annual number of cetacean strandings events has been 2.1, with a maximum number of 5 in 2015. Mass strandings represented ca. 40% of all events, with numbers ranging between 3 and more than 200 animals. No significant differences in number of strandings where observed between the winter (November-April) and the summer (May-October) months. Unfortunately, the lack of technical and logistic resources has made it almost impossible to investigate the potential causes behind these cetacean strandings. To develop a Cabo Verde National Stranding Network which includes; training staff, veterinarian support, capacity building, funding, outreach and education in order to better deal with these events are essential priorities.

Minimizing competition in space and time in a limited marine insular coastal habitat: Cetaceans in the Madeira archipelago.

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Oceanic islands seem to be important for cetaceans, considering their usually high species diversity. Thus, to better understand cetaceans' ecology it is important to study how different, apparently competing, species share limited resources in such usually small insular habitats. From 2001 to 2017, 56 127 km of effort were carried out in Madeira archipelago inshore waters in dedicated line-transect aerial and shipboard surveys, random shipboard surveys and observers on whale-watching and fishing boats. A total of 1177 sightings of 10 cetacean species and two genera were recorded on effort. Data were combined to model the spatial distribution of relative abundance of these taxa using Generalised Additive Models (GAMs), where survey type was a factor covariate, 43 other environmental covariates were explored, and model selection was based on the lower corrected AIC score. Bottlenose dolphins were present year-round, common dolphins mostly in winter and spotted dolphins in spring/summer. Bryde's whales were present in summer/autumn and fin whales peaked in March. The deep diving species were present year-round; sperm whales intermittently throughout the year, short-finned pilot whales peaking in October and beaked whales in August. All species, including the most sighted species, had an overall limited overlap in distribution, with physiographic, productivity and oceanographic related covariates explaining the sightings distribution, but with "mixed layer depth" as a common covariate to all deep diving species. In such a small insular oceanic habitat as Madeira archipelago coastal waters, with higher productivity than the surrounding oligotrophic sea, cetacean species seem to minimize competition for resources by a differentiated temporal and spatial use of the study area, with a few more abundant species taking advantage of the available resources while the remaining species, far less abundant, tend to use these waters while in migration, intermittently throughout the year, further offshore, or opportunistically.

Macroplastic counts at sea in the southeastern Thyrrhenian Sea and northwestern Ionian Sea

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It is evident today that plastic debris is a major threat to cetaceans and other marine life. The Mediterranean Sea has been identified as one of the worldwide "hotspots" for land- and sea-based sources of plastic and microplastics. However, information on the quantitative extent of marine plastic pollution and the temporal evolution of the abundance of floating plastics are still sparce. In the context of a long-term cetacean monitoring project along the northeastern and eastern coast of Sicily (incl. Strait of Messina), Mediterranean Sea, we started to examine the extent of the plastic pollution in the surface waters based on visual debris counts. Floating debris on the water surface has been counted continuously during line transect surveys and recorded on a standardised protocol in 20-minute intervals. Counts were assigned to 12 categories (e.g. fragments, nets, bags, and non-plastics). Density maps (plastic items/km2) have been established. Floating debris has been counted during 916.9 km, 1,233.9 km, and 1,490.4 km in 2016, 2017, and 2018, respectively. Our results confirm that floating debris is ubiquitous as almost no count interval resulted in 0 observed floating items. More than 90% of observed debris consisted of plastic fragments. Highest numbers of floating plastic items have been found in the more northern part of the study area near the Strait of Messina. Our first study results allow to identify local "hotspots" of floating plastic debris in the study area and thus add information about the habitat quality. Our sampling efforts will be continued in the future and complemented by microplastic surface sampling, as well as the analysis of the chemical composition of both floating plastic and microplastic. Moreover, our data may serve as a basis for future modelling approaches to better understand the spatial and temporal distribution of floating plastic debris in the area.

Feeling the squeeze: Antarctic minke whales balance the dual pressures of maximizing energetic gains and finding suitable habitat around the rapidly changing Antarctic Peninsula.

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The Antarctic Peninsula is warming rapidly, manifesting in decreased sea ice cover and changing prey availability. Antarctic minke whales (AMW) are the smallest baleen whale species, yet are the ecosystem's largest ice-affiliated endemic krill predator, and their foraging behavior and ecology remain unknown. Consequently, we lack fundamental information regarding baleen whale foraging ecology and more specifically, how climate-driven changes affect AMWs and related ecosystem dynamics. We use motion-sensor tags combined with scientific echosounder data on prey patch shape, depth, and density to test hypotheses regarding how changes in prey availability influence AMW feeding behavior, foraging rates, and energy gain. Using novel animal-borne video on tags, we measure sea ice presence and concentration at every surfacing event to test hypotheses regarding how AMWs balance the pressures of finding suitable prey while accessing preferred sea-ice habitat. In 2018-9, we deployed 33 tags on AMWs in coastal bays resulting in >400 hours of data. Additionally, we surveyed >430 km for prey availability. Preliminary analyses reveal that AMWs have faster feeding rates than any other baleen whale species, modulated by krill depth and density. AMWs fed throughout the day on a deep and dense krill layer between 100-200m. Krill then migrated vertically at night and dispersed, and minke whales ceased foraging. During daylight hours AMWs spent 52% of their time in open water and only 15% of their time in ice cover greater than 20% suggesting that prey significantly affects fine-scale distribution. Our results 1) provide an emerging understanding of how foraging behavior and energetics scale across baleen whales, 2) help to evaluate the potential for competition with other krill predators (e.g. humpback whales) as ice-free conditions manifest, and 3) provide a foundation for determining how changing sea ice conditions affect the persistence and dynamics of minke whales in this region.

Policy approaches for more sustainable marine wildlife watching

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Since its inception in 1979, the Convention on the Conservation of Migratory Species of Wild Animals (CMS) has produced many resolutions and decisions that contribute to the overall goal of conserving species with an unfavourable conservation status and their habitats. One topic of recent focus is that of marine wildlife watching, including both boat-based activities and in-water interactions. The growing popularity of recreational wildlife encounters has in some areas resulted in unsustainable pressure being put on local animal groups. This has resulted in a benign use of wildlife to turn into a potential threat. Negative effects of unregulated marine wildlife watching activities include changes in habitat use and/or displacement, changes in short-term natural behaviour, chronic stress, changes in energy expenditure with potential negative consequences on individuals and overall population health, as well as injuries and death as a consequence of collision with boats or other motorized vessels. In response to this, particularly with respect to cetaceans, much guidance has been produced, including the 2018 Online Whale Watching Handbook co-produced by the IWC and CMS. CMS has also produced guidance for other affected species groups, namely pinnipeds and sirenians, sharks and rays, marine turtles and sea birds. While to date the focus was mostly on wildlife watching from boats, current and future work is dealing particularly with effects and management of in-water interactions. This poster explores key issues to address and the policy responses to them, outlines gaps and shows the role of different actors in supporting future decision making and facilitating implementation of the agreed actions.

Double Drone Drama: Using two drones to collect simultaneous visual and underwater acoustic behavioural data from gray whales in Baja California, Mexico.

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The gray whale (Eschrichtius robustus) is a coastal baleen whale species that inhabits the North Pacific Ocean. The Eastern North Pacific population breeds and calves during the winter months along the Pacific coast and in lagoons in the west coast of the Baja California Peninsula, including Laguna

San Ignacio. Gray whales produce several different call types in the lagoon, and previous studies suggest that types of sound produce depend on behavioural context. Unmanned Aerial Vehicle (UAV), or "drone", technology, provides an alternative, non-invasive and often cost-effective option for monitoring marine species, with applications to aerial surveys, monitoring, habitat use, abundance estimates, photogrammetry and biological sampling. Here we demonstrate how two drones flying simultaneously can combine visual aerial observations with close-range passive acoustic measurements to better understand the behavioural contexts of call generation. Between 27 February and 17 March, 2019 a field team in Laguna San Ignacio collected aerial visual data using a Phantom 4 Pro (DJI) and acoustic data using a SplashDrone 3+ (SwellPro) equipped with a SoundTrap 300STD (Ocean Instruments). The simultaneous drone footage and acoustic recordings provided insight into the whale's acoustic behavior. Furthermore, call-type-specific source levels can be obtained using the combined acoustic/visual dual-drone approach. For example, the source level of "bubble blast" sounds was estimated to range between 113 to 125 dB re 1 μPa. The proximity of the acoustic drone with the vocalizing whales allowed recordings of a large diversity of calls, some of which were too weak to be recorded by traditional methods. Surprisingly, we also found that surface exhalations (blows) of whales could be detected underwater to ranges of 75 m in calm conditions. This preliminary work indicates how UAVs can provide new relatively non-invasive platforms for underwater bioacoustics, and how multiple UAVs can provide a more integrated snapshot into animal vocalization context.

Population structure of two minke whales species (Balaenoptera acuturostrata and B. bonaerensis) in the southern hemisphere.

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In this study, we assessed the population genetic structure of Antarctic (*Balaenoptera bonaerensis*) and common (*B. acuturostrata*) minke whales in the Southern Hemisphere (SH), with special attention to the potential connectivity between western South Atlantic (WSA) and Antarctic Peninsula (AP). Mitochondrial DNA control region sequences were obtained for 21 samples (AP n=12, North n=1, Southeast n=5, and South Brazil n=3) of Antarctic minke whale and for 10 samples (South Brazil n=9, AP=1) of common minke whale. The latter were compared to sequences previously reported on GenBank (Northeast Brazil n=8; Chile n=3; South Atlantic n=1 and South Pacific n=14 sectors of the Southern Ocean) to infer population structure at larger scale in the SH, totaling 36 sequences (320bp). Antarctic minke whales showed a high genetic diversity (H=0.994; π=0.8%), with 19 haplotypes (715bp) defined by 55 variable sites. No genetic differentiation was found between WSA and AP whales. The mtDNA sequences for common minke whales revealed a high genetic diversity (H=0.860; π=0.5%) with 12 haplotypes (one newly described) defined by 26 variable sites. South Pacific sector samples were genetically different from all other localities. Additionally, animals sampled in the Northeast were differentiated (Fst=0.23; p=0.05) from those of Southeast Brazil. Mismatch distributions and neutrality tests indicated that populations of both species are not in equilibrium and are possibly experiencing a demographic expansion. Our results showed no genetic structuring between AP and WSA for Antarctic minkes based on mtDNA analysis. Such lack of structure has been previously reported for common minkes in the SH. However, we pinpointed a possible population subdivision within the WSA for *B. acuturostrata*. Such findings are important for better understanding the population structure and the migratory connections of minke whales in the SH, and should be complemented with other molecular markers for obtaining finer-scale results.

Antimicrobial resistance determinants in free-ranging Australian pinniped pups.

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The rapid emergence of antimicrobial resistance (AMR) is a major concern for wildlife and ecosystem health globally. The clinical class 1

integron is a mobile AMR determinant used as an indicator of anthropogenic pollution, being rarely present in environments less affected by humans. We previously identified a class 1 integron in an *Escherichia coli* isolate from a single Australian sea lion (*Neophoca cinerea*) pup indicating that AMR determinants are polluting marine systems. The objective of this study was to determine the distribution and prevalence of class 1 integrons in the faecal microbiome of neonatal *N. cinerea*, Australian fur seal (*Arctocephalus pusillus doriferus*) and long-nosed fur seal (*Arctocephalus forsteri*) pups from eight breeding colonies along the Southern Australian coast. A subset of faecal samples (300 of 824) and *E. coli* (*n*=682) isolated from 824 faecal samples collected from 2016-2019 were analysed for class 1 integrons using PCRs targeting the conserved integrase gene (*intI1*). Class 1 integrons were detected in 14% of faecal samples (*n*=42) and 7.4% of *E. coli* isolates (*n*=51). Positive samples were from seven of the eight colonies investigated and in all three species sampled. The highest prevalence was in *A. p. doriferus* (12.5%), followed by *N. cinerea* (5.4%) and *A. forsteri* (1.6%). DNA sequencing of the variable gene cassette region identified diverse genes conferring resistance to six antibiotic classes.

The results of this study suggest that all three species are exposed to anthropogenic pollution with the carriage of AMR determinants demonstrating the extent that resistant bacteria have polluted the marine environment. As AMR determinants are frequently associated with bacterial pathogens, their occurrence suggests that all three pinniped species are potentially vulnerable to further anthropogenic pollution and unknown health risks. The implications of AMR carriage for individual and population health are a key focus of ongoing investigations.

Behayve: Configurable iPhone app maps behaviors and tracks with real-time display, integrating with ArcMap™ and supporting focal, scan, behavior and ad libitum sampling.

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Researchers from Australia's Living Ocean NGO have developed and deployed a **configurable cellphone app** that **integrates the capture of behavioral, tracking and environmental data**. Concurrent focal, scan, behavior and ad libitum sampling is supported with the ability of behaviors to have multiple roles and modifiers.

Each behavior in a custom ethogram may be illustrated with a sample image, video or audio clip for reference.

Animal **behaviors and tracks, along with associated data, are displayed on the device in real time** using a Google™ map or custom onboard map, affording immediate insight. A predictive function suggests the present position of animals, useful in relocating lost targets.

Data is gathered by manual or automated means. **Range can be captured automatically from a wireless laser rangefinder**, and **compass bearing by putting a target in the crosshairs onscreen**. **Data from ship's instruments,** such as water depth and temperature, may also feed in over a wireless connection via a serial-to-wireless adapter.

Data may be reviewed and corrected at any time and may be **synced to the cloud or a laptop**. Positions can be determined even where SatNav is unavailable, using a grid map and relative positioning.

I**ntegration with ArcMap™ GIS allows voluminous data to be effortlessly displayed** in organised form with extensive labor saving. A mixture of SatNav and grid-map observations can be seamlessly displayed. **Google Earth™ and Google My Maps™** are also supported**.** Selecting an observation on the map displays associated data.

A facility is provided to sync data between the cellphones of colleagues at different locations.

This fully autonomous app can be re-configured in the field and is suitable for non-invasive studies of marine, terrestrial and avian species even in the most challenging environments. Most recently the app has been utilised successfully in an extended humpback study and is now being offered for review and feedback.

Plasma and fecal sex steroid analysis for monitoring reproductive function in captive Risso's dolphins.

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The Risso's dolphin *Grampus griseus* has a worldwide distribution in tropical and temperate waters. Despite their wide distribution, the life history of this species is poorly known. A better understanding of the reproductive biology and physiology of the species is essential for effective conservation and management of wild dolphin populations. The present study aimed to monitor gonadal function by means of plasma and fecal sex steroid analysis in five sexually mature captive Risso's dolphins (two males and three females). Blood samples were collected once per month in males and twice per month in females, and fecal samples were collected once per week in males and at 2–3-day intervals in females over a one year period. Plasma progesterone (P_4), estradiol (E_2), and testosterone (T) were quantified by fluorescence immunoassay, whereas fecal progestagen (iP), estrogen (iE), and androgen (iA) metabolites were quantified by enzyme immunoassay. Fecal steroid metabolites profiles tended to appear similar to plasma steroid profiles. T and iA levels in males showed seasonal changes, with an increase from spring to autumn. High P_4 and iP levels were detected in two females during pregnancy, and cyclic rises of P_4 and iP returned one month after neonatal death and two months after parturition, in one female. The estimated mean (± SD) these cycle length was 34.4 ± 4.6 days (n = 4). In the other female, prolonged cyclic P_4 and iP elevations with an iE peak before elevations were detected during the study period; the estimated mean cycle length was 102.3 ± 22.1 days (n = 4). This report is the first to characterize reproductive physiology in Risso's dolphins. These findings demonstrate that the two females exhibited two different types of physiological cycles, and further investigation is necessary for understanding this phenomenon, including the normal estrus cycle length in this species.

Songs of fin whales in the southern Chukchi Sea

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Songs, which consist sequences of sounds produced repeatedly, have been produced by some baleen whales mainly for reproductive functions. Fin whale songs consist of regular sequences repeated 20 Hz pulses. Based on their Inter-pulse intervals (IPIs), their songs can be classified into some types. These types show geographic differences, therefore, song structure is suggested to indicate population or stock structure. After the dramatic transformation of the marine ecosystem in the Pacific Arctic and recovering from depletion by commercial whaling, the number of migrating fin whales appears to be increased in this area. However, little is known about song features and group structures in this area. In this study, we aimed to reveal the song types in the southern Chukchi Sea and to examine the group structures of fin whales in this area.

We used an Automatic Underwater Sound Monitoring System (AUSOMS; AquaSound Inc., Japan) to record fin whale songs from July 2012 to June 2015 in the southern Chukchi Sea. We selected 1-hour data every week of call detection periods and measured IPIs of the songs. Based on IPIs, song types were classified and compared with the previous research to investigate similar song types.

Songs were recorded from August to November in 2012–2014. Only one type with two IPIs (10.51±1.40 s and 19.56±3.92 s) was observed. It is suggested that only one group migrated to this area. However, this song type was different from the previously reported song types in the Bering Sea and Northern Chukchi Sea recorded in 2007–2010. Future research is needed to compare with the song of the other sea area of the same year.

Feeding ecology of narrow-ridged finless porpoises in Ise and Mikawa Bay, central Japan, using carbon and nitrogen stable isotope analysis.

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Stable isotope analysis is a powerful tool for understanding food habits. We analyzed carbon and nitrogen stable isotope ratios ($\delta^{13}C$, $\delta^{15}N$) of narrow-ridged finless porpoises (*Neophocaena asiaeorientalis*) in Ise and Mikawa Bay, central Japan, to understand their food habits. A total of 199 muscle samples (94 males and 105 females) were collected from dead individuals via bycatch and stranding from 1994 to 2018. Relation of $\delta^{13}C$ and $\delta^{15}N$ with sampling month, year, area, sex and body length was analyzed by Generalized Additive Models. Akaike's Information Criterion (AIC) was used for model selection. Lowest AIC indicated the best model. For both $\delta^{13}C$ and $\delta^{15}N$, explanatory variables of the best models were sampling month, year and body length. Sex and sampling area were

not selected. Data indicated that $\delta^{13}C$ and $\delta^{15}N$ decreased over 25 years, possibly due to variations in stable isotope ratio of primary producer or sea water in the study area caused by environmental changes. In general, $\delta^{13}C$ and $\delta^{15}N$ were low in February and March. Furthermore, $\delta^{13}C$ and $\delta^{15}N$ showed high levels after birth and gradually decreased with growth until a body length of 1.1 m was reached. In addition, trends of $\delta^{13}C$ and $\delta^{15}N$ apparently changed at a body length of 1.4 m, which was regarded as length at sexual maturity. These results suggest that: 1) food habits of finless porpoises are not different for males and females; 2) finless porpoises move back and forth between the two bays; 3) food habits of finless porpoises do not differ each year; 4) feeding location and food habits change with season; 5) newborn calves wean till a body length of approximately 1.1 m is reached, and 6) food habits change at sexual maturity.

¡Hurry, up up! The hematocrit development of an oceanic top predator:The Gudalupe fur seal.

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Hematocrit (Hct) is related to diving and foraging behavior of oceanic top predators such as the Guadalupe fur seal (*Arctocephalus philippii townsendi*) (GFS), which perform the second longest foraging trips (up to 600 km) among otariid species. The aim of this study was to estimate the ontogeny of GFS Hct from the neonatal to adult stage of free-ranging individuals on Guadalupe Island during 2016 and 2017. Blood was collected (EDTA tube) from the gluteal vein, and using a capillary tube, was processed on an automated analyzer. The median and standard deviation for age classes were calculated, and ANOVA and Tukey test were performed to identify potential differences between weight, age class and sex. Neonates exhibited the lowest Hct values (40.7 ± 3.7%; n= 50) followed by weaners (45.4 ± 5.6%; n= 58) and juveniles (44.9 ± 3.1%; n= 25) with the highest Hct observed in adults (48.1 ± 6.2%; n= 21; only samples from females were collected). Hct% was not related to weight and sex ($p > 0.05$) between age classes. Significant differences were observed only between neonates and adults. Our results demonstrate that, from early growth stages, GFS develop efficient and suitable oxygen stores to carry out long trips regardless of sex. Thus, these potential movement capacities could be linked to a recent high dispersal GFSs that eventually ended up in strandings of emaciated weaners and juveniles along the California Coast, including southern areas in Mexico. Knowledge of variation in Hct among age groups is vital for our understanding of the ecology and biology of the species. It is also an important parameter of health assessment, particularly relevant as warming ocean waters affect prey availability which in turn affects foraging ecology, nutrition, and survival.

Humpback whale (Megaptera novaeangliae) reproductive success takes a dive in Alaska during and after the North Pacific marine heatwave.

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Consistent long-term population monitoring by National Park Service biologists in Glacier Bay and Icy Strait, southeastern Alaska has used individual-identification to document the number of different humpback whales and the number of calves in June-August annually since 1985. After many years of considerable reproductive success, these whales experienced a sudden, sharp decline in productivity and juvenile survival beginning in 2014, following the onset of the marine heatwave that dominated the northeastern Pacific Ocean from late 2013-2016. In 2014-2018, humpback whale calving rates in the study area were much lower than historic levels. The crude birth rate (defined as the number of calves divided by the total number of whales) was significantly lower in 2014-2018 (mean = 2.8%) than in 1985-2013 (mean = 9.3%). At the same time, we documented elevated calf mortality rates (36%-100% per year) with 7 of 23 calves in 2014-2018 no longer with their mother and presumed dead by fall, compared to only 8 of 270 calves missing over all previous summers (1985-2013). None of the 22 calves born in 2014-2017 have returned as juveniles or been documented elsewhere in southeastern Alaska, suggesting a decline in juvenile survival as well. Observations of low numbers of whales and calves elsewhere in southeastern Alaska since at least 2016 indicate that these declines are not unique to the Glacier Bay area. Unusually warm waters during the heatwave have been implicated in a wide variety of cascading marine ecosystem effects. Our findings suggest that poor maternal body condition and offspring survival resulted from widespread, significant, and lasting changes to whales' forage fish and zooplankton prey base that began during

the heatwave. Applying rigorous long-term monitoring efforts to whale populations in a variety of habitats would greatly benefit scientific understanding of current and future effects of climate change on marine food webs.

Long-term prey selection of polar bears in a region of rapid ecological change in the eastern Canadian Arctic

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Declining sea ice will negatively affect polar bears (*Ursus maritimus*) via habitat degradation and reduced foraging opportunities. However, diversity and availability of prey, and regional environmental conditions may influence the rate and severity of the impacts of sea ice loss. We investigated spatiotemporal changes in polar bear diet over 18 years in Foxe Basin and tested the hypothesis that polar bear scavenging on bowhead whale (*Balaena mysticetus*) carcasses has increased over time, mediated by increased subsistence harvest and killer whale (*Orcinus orca*) predation. We analyzed adipose tissue from 358 polar bears harvested from 2010 - 2017 and archived fatty acid data from 109 polar bears harvested from 1999 - 2003. Individual diets were characterized using quantitative fatty acid signature analysis. Polar bear diet varied spatially across 3 regions within the subpopulation: Hudson Strait, northern Foxe Basin, and southern Foxe Basin. Ringed seal (*Pusa hispida*) and bearded seal (*Erignathus barbatus*) were the primary prey in all 3 regions, followed by harp seal (*Pagophilus groenlandicus*) in Hudson Strait, harbour seal (*Phoca vitulina*) in southern Foxe Basin, and walrus (*Odobenus rosmarus*) in northern Foxe Basin. Bowhead whale was found in similar proportions across all 3 regions within Foxe Basin. We also found bowhead whale consumption and frequency of occurrence in polar bear diets has increased over time across the subpopulation. Bowhead whale was present in 42% of bears from 1999 - 2003 and 97% of bears from 2014 - 2017. Our results suggest that scavenging on bowhead whale carcasses has become increasingly common, and polar bears in Foxe Basin may be shifting to alternative prey in response to environmental variability. Increasing abundance of killer whales in Foxe Basin may be indirectly benefitting polar bears via the provision of bowhead whale carcasses and potentially helping mitigate the demographic effects of declining habitat, at least in the near term.

20 years of coastal dolphin population surveys in the eastern Mediterranean

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In the Eastern Mediterranean Sea, few studies have been preformed on cetacean populations. Although a handful of research cruises have been executed- no long term ecological research has been conducted, with the exception of the Israeli coast (196 km). In 1998, IMMRAC (Israeli Marine Mammal Rescue and Assistance Center) began its near-shore monitoring program for coastal dolphins. Between the years 1998 – 2018 ; 782 ship-board surveys covered a total of 18,802 NM and 247 dolphin sightings were recorded. Surveys were carried out year round, with totaled-surveys-per-month ranging between 49-83, and totaled-sightings-per-month ranging between 14-27. The majority of effort concentrated on the central and Northern regions of the country's coastline, though in recent years, regular surveys begun in the South as well. Search patterns were mostly random- covering areas between the depths of 30-60 meters, though when nearing a trawler or fish farm- course is changed to search their surroundings, as dolphins are often associated with the two, due to the availability of food around them. Data recording methods have evolved over the years- starting with handwritten notes and culminating into a versatile phone app- DELPHIS, that enables all researchers to conveniently collect data during any outing to sea. Over these last 20 years changes in species presence and distribution have been observed: *Tursiops truncatus* - had been present along the entire coastline- has become scarce in the north

since 2013, while *Delphinus delphis* – that had appeared absent from Israel's coast, has been observed in the South from 2009 onwards. The changes observed in dolphin distribution may reflect small-scale environmental changes or anthropogenic affects, but could also reflect larger basin-wide changes in the Eastern Mediterranean region where knowledge is lacking. To better assess the variation in distribution, further research is underway- modelling environmental variables that shape dolphin habitat preferences.

Investigating the seasonal effect of disturbance on the energetics and population dynamics of a marine predator

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For marine species that depend on sound to navigate, forage, and communicate, anthropogenic noise can affect population dynamics and conservation status. However, predicting the impacts of noise on a population requires an understanding of how disturbances affect the physiology, energetics, and fitness of individuals. Here we present a mechanistic, spatially realistic individual-based energetic modeling framework for simulating the effects of nonlethal disturbances on marine populations. We use the model to evaluate the effect of anthropogenic noise from seismic surveys on a marine species that has been noted to have exceptionally high metabolic costs, the harbor porpoise, *Phocoena phocoena*. This model serves as a novel approach to evaluate the threat of disturbance both seasonally and spatially to identify not only where but also when a disturbance may most endanger a population, allowing for better informed marine management and spatial planning.

Influence of environmental factors on the spatial distribution of two harbour porpoise subpopulations in the Baltic Sea

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The harbour porpoise (*Phocoena phocoena*) is a highly mobile cetacean found in coastal waters across the Northern hemisphere with different subpopulations in European waters. Since the SAMBAH project the continued existence of the critically endangered Baltic Proper (BP) porpoise subpopulation east of the Darß Sill and south of the Limhamn Sill is no longer in doubt. This subpopulation differs genetically, morphologically and ecologically from the subpopulation of the Belt Sea (BS). Porpoises furthermore inhabit water basins that vary broadly in salinity, temperature, and food availability potentially driving differentiation among (sub-)populations. To study the habitat use of porpoises, we deployed C-PODs in the German Baltic Sea for up to nine years on up to 15 positions nearly continuously. We calculated porpoise positive days and hours to provide unbiased estimates of local occurrence rates. These data are modelled in dependence of abiotic environmental variables assumed to be good indicators of lower trophic level species distribution and thus potentially good proxies of top predators' distribution such as distance from the shore, slope, depth, sea surface temperature and salinity. This habitat modelling serves as the basis to determine which population was recorded on the hydrophones. We reproduce an approach presented by Gallus et al. 2012 using a proxy station for the occurrence of the BS subpopulation by selecting a reference position in western German Waters under the hypothesis that porpoises from the BP show differences in habitat use, especially in winter times. Studying the spatial distribution of these cetaceans can provide crucial data essential for the design of efficient conservation strategies.

Complex social Interactions of sperm whales (Physeter macrocephalus) in the Strait of Gibraltar: The sighting of a marguerite formation with the probable presence of a calf.

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The sub-population of sperm whale (*Physeter macrocephalus)* resident in the Mediterranean Sea shows a spatial distribution dependent on various factors. Particularly, spring and autumn movements are observed between the West basin and the Strait of Gibraltar, normally attributed to adult and subadult males in a foraging behaviour. In this

study, we describe a complex sperm whale behaviour observed in the Strait of Gibraltar on September 25th, 2017. The sighting consisted in a gathering of at least 10 individuals performing a marguerite formation, a typical defensive behaviour in order to protect an individual of the group. In fact, a considerably small individual was observed in this formation, surrounded by pilot whales and bottlenose dolphins. Therefore, it is highly probable that the formation was taking place to protect a calf or a juvenile. During the sighting, photos of the individuals were taken and further compared to the photo-ID Turmares Tarifa catalogue of the Strait of Gibraltar. The results did not match with any of the individuals in the catalogue. We presume new individuals may have approached the area, and the possible presence of a young individual could mean the presence of females. The occurrence of females with youngsters, if repeated, could potentially represent a new use of the area by sperm whales, and would enhance the importance of the Strait of Gibraltar in the conservation of the species.

"Small delphinids" identification: From scientific confusion to conservation issues.

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Taxonomic confusion can lead to misestimation of population and to lack of accurate data guaranteeing a reliable conservation status assessment. Small delphinids have been confused since ancient times, and unfortunately it is still the case for other reasons. Ancient scientists as Aristoteles only distinguished 'dolphins' from fishes or from whales. Renaissance scholars already stated differences between several vernacular names for the presumed same animals, whereas several similar species could be confused under the same name, as 'dolphin' and 'porpoise'. For example, the striped dolphin (*Stenella coeruleoalba*) presumably inhabits the Mediterranean Sea since centuries without being specifically described, as a proper name (and precise associated identification criteria) was missing until the middle of the 19th century (before Gray and Gervais). This situation led to misidentifications and confusion with the so called "common dolphin", *Delphinus delphis*, considered as the only common dolphin in the area or used as a generic name. Finally, the name "*delphinus coeruleoalbus*" was retroactively given after Meyen, who described and sketched this animal off Brazil (1833), during a German expedition on the *Prinzess Louise*. Consequently, the striped dolphin Mediterranean presence was certainly underestimated. But, whereas the difference seems now clearly established, the status of the common dolphin remains uncertain in the Mediterranean Sea: geographical repartition, abundance trends remain in question. This taxonomic confusion is still observed and can lead to an incorrect assessment of present species conservation status. Moreover, the latest method for abundance estimation, by aerial survey, is likely to reduce knowledge instead of increasing, because both dolphins are often processed under one single appellation, "small delphinids". In case of fisheries bycatch issues, such as in the Bay of Biscay, the conservation status of each species is regrettably again unsure, because 'safe' bycatch thresholds are expressed as a fraction of population estimates (for example 1%).

This must be the place: Habitat preferences of pelagic bottlenose dolphins in the Northeast Atlantic.

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Understanding spatio-temporal variations of habitat use is fundamental when designing appropriate conservation schemes for cetacean populations. In the Northeast Atlantic, pelagic bottlenose dolphins (*Tursiops truncatus*) are genetically and socially distinct from coastal populations, but their habitat preferences are unknown.

To investigate how the presence of these pelagic dolphins relates to environmental parameters, we developed generalised additive models (GAMs) using data from aerial surveys of the Irish EEZ over two summers and two winters. Binomial GAMs were trained on the two later seasons. Models were first run across the entire study area, and then including an interaction term with habitat type, dividing the region into continental shelf, slope, and abyssal waters. Their goodness of fit and predictive capacity were tested on concurrent data and on observations from the first two survey seasons.

Sea surface and bottom temperature, mixed layer depth, primary productivity, seabed aspect and rugosity all played a significant role in bottlenose dolphin distribution, as did proximity to the

coastline and various depth contours. Most covariates were only significant in one season. Notably, including the interaction term altered the effect of most variables on dolphin presence, with some predictors only appearing significant in shelf or slope waters and the shape of the relationships changing between habitats. Higher probability of dolphin occurrence was predicted near the southwest coast in summer and throughout most of the continental shelf and slope in winter. Predictions were less accurate for the first two seasons, possibly reflecting variability in habitat use over longer periods than those investigated here.

This baseline study of pelagic bottlenose dolphin habitat use in the Northeast Atlantic increases our understanding of how their distribution relates to environmental factors. Our results highlight that this population's habitat preferences are season- and habitat-specific, which will help inform marine spatial planning.

Spatio-temporal and inter-individual variations in trophic ecology of the manatee in the Mexican Caribbean: Carbon (δ13C) and nitrogen (δ15N) isotopic composition from bone-collagen over the last 30 years.

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The Endangered Antillean manatee (*Trichechus manatus manatus*) inhabits marine, estuarine and freshwater environments, feeding on a wide variety of aquatic and semi-aquatic plants, having an important role in the trophic cycle of these ecosystems. Preliminary studies have revealed the diet of Antillean manatees in the Mexican Caribbean by analyzing stomach contents and feces. However, studies on manatee trophic ecology that allow to infer spatio-temporal variations in the diet of the species have not been carried out in the area. A total of 68 bone-collagen samples, collected between 1986 and 2017 in Quintana Roo, were analyzed isotopically ($\delta^{13}C$ and $\delta^{15}N$). Mean (± SD) carbon ($\delta^{13}C$) isotopic composition was -9.44 ± 2.62, ranged between -17.95 ‰ and -3.38 ‰; and mean nitrogen ($\delta^{15}N$) isotopic composition was 6.03 ± 1.57, ranged between 2.21 ‰ and 9.97 ‰. No significant differences in $\delta^{15}N$ and $\delta^{13}C$ were found among decades, sex and age class ($p > 0.05$). However, significant differences were found among locations ($p < 0.05$) in $\delta^{13}C$, but not for $\delta^{15}N$ ($p > 0.05$). Our results of stable isotope analysis in bone-collagen, show manatee feeding behavior in the Mexican Caribbean, specifically the use of seagrasses in compared to freshwater and/or brackish vegetation; also suggest that in despite of the habitat modification in the region over the last 30 years, the feeding habitats of this manatee population have remained without significant changes.

Ocean missions: Towards a long term citizen science program to protect the Arctic.

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Clear evidence worldwide shows that most of our oceans and seas are highly polluted with marine litter, particularly plastics and fishing gear, among other types of toxic products. Iceland is home to more than 20 different species of cetaceans, including endangered blue whales (Balaenoptera musculus), fin whales (Balaenoptera physalus) and even rare hybrids. Some of the largest and most threatened colonies of seabirds such as the Atlantic puffin (Fratercula artica) can still be spotted here. While wildlife watching is now one of the most attractive touristic activities, whaling and hunting of threated species including seals still occurs. During the week-long pilot project expedition April 2019 we conducted floating plastic surveys (>1 mm) with a Low-tech Aquatic Debris Instrument (LADI) manta trawl. Plastics were present in all the study areas (n=6) including cod spawning areas and strategic whale feeding grounds. Fishing lines and fibers were the most abundant particles. Furthermore, fishing gear was also present on beaches (n=2), remote nesting colonies and even entangling bird´s bodies. Pure science seems to be not enough to make a rapid change in a fast changing marine environment. Ocean Missions wants to inspire and engage people to take straight action towards ocean conservation supporting

scientific efforts by a combination of science, education and adventures sailing in the fragile Arctic and Sub Arctic regions

First evidence of OPFRs presence in fin whales.
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The fin whale, *Balaenoptera physalus* (Linnaeus, 1758), is a cosmopolitan cetacean. It is found in most of the world oceans, where it performs annual migrations between low-latitude breeding areas and high-latitude feeding areas. During these long-range migrations, fin whales cross water masses that may be contaminated by different types of pollutants, including the ever-increasing marine litter. Physical adverse effects of marine litter on cetaceans are well known and include entanglement, suffocation, and obstruction of the digestive system. However, chemical effects related with the ingestion of marine litter, and particularly of plastic, are still under assessment, and have been mostly associated with the toxicity of plastic additives and plasticizers. Among the compounds involved in the production of plastic, organophosphate flame retardants (OPFRs) might cause adverse reproductive, endocrine and systemic effects in long-term exposed animals. In this study, we analyzed OPFRs concentrations in the muscle of North Atlantic fin whales and in samples of its main prey, the krill *Meganyctiphanes norvegica*. 19 OPFR compounds were measured in 20 samples of fin whales and 10 samples of krill collected in 2015 in Iceland. 7 and 5 out of 19 OPFR compounds were detected in fin whale and krill samples, respectively. IPPP (Isopropylated Triphenyl Phosphate), TNBP (tri-n-butyl phosphate) and TPPO (Triphenylphosphine oxide) were the most abundant compounds in both types of samples. Mean ∑OPFR (the sum of all OPFR compounds measured) concentration, expressed on a lipid weight basis, was 985 (SD=2,239) $ng g^{-1}$ in fin whale muscle, and 949 (SD= 1,090) $ng g^{-1}$in krill. These results do not suggest a biomagnification of OPFRs, but provide a first evidence of their presence in fin whale tissues.

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Resource partitioning between five species of mysticeti inhabiting Icelandic waters

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The high productivity of waters off Iceland makes this area an important summer feeding ground for baleen whales. The blue whale (*Balaenoptera musculus*), the fin whale (*Balaenoptera physalus*), the sei whale (*Balaenoptera borealis*), the common minke whale (*Balaenoptera acutorostrata*) and the humpback whale (*Megaptera novaeangliae*) are frequent visitors in the region. Coexistence in the same habitat of species with similar ecological requirements often entails spatial or trophic segregation to avoid competitive exclusion. With the aim of studying how these species share habitat and trophic resources, we analyzed the $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ values in 90 skin samples obtained from them. Preliminary results evidenced substantial niche partitioning between most of the species. The only exceptions were fin and blue whales, whose isotope ratios overlapped highly. Minke and humpback whales showed relatively higher $\delta^{15}N$ values, probably reflecting a larger contribution of fish in their diet. However, these two species presented dissimilar $\delta^{13}C$ values, the minke whales being more enriched in ^{13}C than humpback whales, thus suggesting some degree of allopatry. In contrast, sei whales had lower $\delta^{15}N$ and higher $\delta^{13}C$ values than blue and fin whales. Overall, our results support limited interspecific competition between the species, with the only possible exception of blue and fin whales, that appear to share ecological resources.

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Can elemental analyses in narwhal tusks reveal population structure and environmental changes?

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The long, spiralled tusk of the narwhal (*Monodon monoceros*) is unique not only because of its exceptional form and structure, but because the tusk potentially contains information about the life history and environment of its owner.

The narwhal tusk itself provides a chronological framework. It is built of dentine layers – one for each year in the whale's life – containing major and trace elements incorporated during growth. The resulting elemental composition, and any variations in it, has the potential to serve as an environmental and area specific record. As narwhals are long-lived, with tusks that grows continuously throughout their lifespan, the tusk can provide unique habitat information in time and geographical space using elemental analyses.

Narwhal tusks from Greenland, spanning a time period of ~75 years, from the 1940's to 2018, have been collected with the purpose of constructing profiles including age, elements, isotopes, Carbon-14 and hormones. This on-going study investigates the elements in each tusk layer using two methods: X-ray fluorescence spectrometry (XRF) and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). Our hypothesis is that the elemental profiles of whole tusks can uncover the location of the whales at a specific time (summer/winter grounds and migration routes), and thereby population structure, and the environmental changes these areas underwent during the lifetime of the whales, hereunder the influence from climatic changes that have occurred during this period.

Tusks have successfully been mapped using XRF and elemental profiles are constructed using LA-ICP-MS. Preliminary results show a clear variation of some elements, e.g. Strontium and Zink, through the layers. We are currently working towards identifying the most likely cause of these variations, and correlating them within a chronological framework that includes independent temperature records from narwhal specific areas. The results of this work will be presented at the meeting.

Spatial and temporal distribution of humpback whales (Megaptera novaeangliae) in the Babuyan Marine Corridor, northern Luzon, Philippines.

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Humpback whales wintering in the northern Philippines belong to the western North Pacific subpopulation, now recognized as a distinct population segment. The numbers for this subpopulation are low and in the Philippines threats are apparent in the breeding ground. We are presenting the spatial and temporal distribution of humpback whales in the Babuyan Marine Corridor breeding ground from 2001 to 2019. Surveys were conducted during the season from February to May. Based on our analysis of 1,078 sightings, mother-calf (MC) pairs generally preferred shallower waters while all other group types occurred in a wider range of depth. In particular, competitive groups (CG) were found, on average, at waters >200m deep. This habitat preference coincides with other literature on humpback whale breeding grounds. Based on departure date and sighting role type proportion analysis, different group types also showed patterns of arrival and departure times wherein MCs leave the latest while CGs leave much earlier. This pattern appears to be shifting progressively earlier in the season, as the median and average proportion of MC sightings have increased over time, and CGs have not been sighted since the 2015 season. These results suggest that recent surveys are observing later stages of the breeding season's departure pattern than earlier survey years, particularly since 2016, at least around one island. Therefore, our data suggest that humpback whales in the Babuyan Marine Corridor segregate themselves spatially and temporally according to role type, and that while temporal distribution patterns appear to remain relatively consistent in terms of departure order, the actual departure dates of different role types are shifting earlier, possibly in response to warming sea temperatures as a result of El Nino events. Understanding patterns of spatial and temporal distribution is important in the planning for the protection of breeding grounds of this threatened subpopulation.

When revolutions fail: Understanding the underlying mechanisms of humpback whale song revolutions through investigating failures.

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Male humpback whales (*Megaptera novaeangliae*) sing a long, stereotyped, and culturally transmitted song display. Multiple humpback whale song revolutions (where a song introduced from a neighboring population rapidly and completely replaces the existing song) have spread across the South Pacific region from the east coast of Australia to French Polynesia. This has occurred repeatedly in each of the five western and central South Pacific populations until reaching French Polynesia, where the song revolutions periodically failed. Here, we investigate how undocumented population substructure, aberrant singers, and/or potential bidirectional introductions may contribute to revolution failure. Song unit sequences were extracted from over 2,000 phrases recorded across French Polynesia (Society, Gambier, Tuamotu and Austral archipelagos) from 2009-2015, to allow fine-scale analysis of composition and sequencing to understand subpopulation structure. Two decades of theme sequences in French Polynesia (1998-2015) were also analyzed to understand the overall song progression in the central Pacific. Clustering of song phrases using the Levenshtein distance indicated potential subpopulation structure across the region. Structure resulting in reduced residency times in migratory locations may contribute to song revolution failure. Understanding the mechanisms driving song revolutions and the factors that may disrupt this phenomenon will have wide-reaching implications for our understanding of song learning, song evolution and cultural transmission in non-human animals.

Searching for humpback whales two centuries post-whaling: What is left in the Chesterfield-Bellona archipelago?

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Humpback whales (**Megaptera novaeangliae**) were severely depleted by commercial whaling throughout the 19th and early 20th centuries. Understanding key factors of their recovery is a crucial step for their conservation worldwide. In Oceania, the Chesterfield-Bellona archipelago was one of the primary humpback whale whaling sites of the 19th century, however, given its remoteness, it has remained almost unaffected by anthropogenic activities since then. In this study, we report on the first large-scale multidisciplinary dedicated surveys conducted in the Chesterfield-Bellona breeding area to assess the current status of humpback whales in this region two centuries post-whaling. Surveys were conducted in 2016 and 2017, totaling 24 days of effort and 57 groups were encountered. From these groups 13 whales were identified with photo-ID, 16 with genotyping and 22 with both methods. A total of six whales were equipped with satellite tracking devices. The density of humpback whales was relatively low (0.041 whales/km surveyed on average), with the highest concentrations found in the inner shallow waters of the reef complex and the neighbouring off-shore shallow banks. Surprisingly for a breeding area, the sex ratio was very skewed towards females (1M:2.8F). A large proportion of the groups encountered included a mother and calf (45%), especially in the most sheltered waters south of the Chesterfield plateau. Photo-ID and genetic comparisons suggest a strong connectivity with the New Caledonian South Lagoon breeding area to the east, but no connectivity has been detected to-date with the Australian Great Barrier Reef breeding population to the west. Satellite-tracking of three females (including one with calf) suggest use of the South East Australian migratory corridor at least during south-bound migration This study revealed that humpback whales are still inhabiting the Chesterfield-Bellona archipelago two centuries post-whaling, potentially playing a connecting role across breeding grounds of the western South Pacific.

The trophic ecology and habitat of the Gulf of Mexico Bryde's whale

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The Gulf of Mexico Bryde's Whale (GoMex Whale, *Balanoptera edeni*) primarily occupies a discrete habitat near the shelf-break in the Northeastern Gulf of Mexico. This small, genetically isolated population has recently been listed as Endangered under the US Endangered Species Act, and it is important to characterize essential habitat requirements to aid in recovery planning and conservation. We examine the feeding behaviors and trophic ecology of the GoMex whale to better understand the physical and biological features of its limited habitat. Large vessel survey data demonstrate that GoMex whales occur within a restricted depth range between 178-408m and are observed most frequently near the 200m isobath. Data from telemetry tags indicate that during daylight hours, the whales dive to depths between 200-280m and execute feeding lunges near the bottom. Multi-frequency scientific echosounder data show a concentrated layer of organisms near the bottom during daylight hours with the highest acoustic backscatter occurring in the 185-220m depth range. In areas where whales are observed, these potential prey form dense patches which extend for horizontal distances ranging from 0.9 to 3.7 km and vertically from 5-10m above the sea floor extending 20-30m upward into the water column. The multi-frequency response of these aggregations along with the observed schooling behavior are most consistent with dense patches of small pelagic fishes. Mesoscale circulation patterns contribute to the high concentration of prey as there is persistent along-shelf flow of water near the shelf edge along with an inner-shelf convergence zone that may entrain highly productive shelf water. We characterize spatial and temporal variation in the structure of these prey patches within the GoMex whale habitat and demonstrate correlations between current fields, prey patches, and whale occurrence. Ongoing surveys that include trawl collections of potential prey will identify these key trophic resources of the GoMex whale.

The evolution of emergency response approach to the management of large-scale marine mammal mortality events

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During the last three decades, sixteen Unusual Mortality Events (UME) have been formally declared along the northeast coast of the United States. An UME is defined under the Marine Mammal Protection Act as *"a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response."* Responses to these events encompass approximately 4,000 pinnipeds, 1,800 small cetaceans, and 300 large whales. Investigation of UMEs requires significant amount of resources to manage events and research causative factors. From 2013-2015, an UME was declared for common bottlenose dolphins *(Tursiops truncatus)* spanning the eastern seaboard from New York through Florida. Due to the expansive response area, number of response organizations, and jurisdictions of multiple government agencies, a common emergency response framework based upon the Incident Command System was implemented to manage the complexity of the event. Subsequently, in the same region four additional UMEs have been declared since 2016 for humpback whale (*Megaptera novaeangliae),* North Atlantic right whale (*Eubalaena glacialis*), minke whale (*Balaenoptera acutorostrata*), and harbor seal (*Phoca vitulina*) and gray seal (*Halichoerus grypus*). Resources from stranding response organizations and government agencies (financial, but also logistic and personnel) are required to respond to the increased number of stranded animals among all four simultaneous and ongoing events. Emergency response frameworks have been refined for the most recent events based on a comprehensive after action review and lessons learned. The emergency response framework, including disease surveillance, testing, analyses and research plans, for the recently declared UMEs will be summarized, and recommendations for management of future events responding to increased levels of live animal strandings and mortalities will be provided.

Further insight into fin whale subpopulation structure in the eastern North Atlantic.

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Highly migratory marine species pose a challenge for the identification of management units due to the absence of clear oceanographic barriers. The North Atlantic fin whale was subject to intense whaling operations during the 20th century and since then has recovered with varying degrees of success between locations. Subpopulation structure has been investigated through several methodologies since the 1960s but it is still the subject of an ongoing scientific debate. Here we measured stable isotopes of carbon, nitrogen, and oxygen in skin samples from 151 fin whales collected in Iceland, Galicia (NW Spain), the Azores archipelago and the Strait of Gibraltar. In Gibraltar and Galicia, samples were collected all year long from three age classes (calf, juvenile, adult), while samples from the Azores and Iceland consisted in only adult whales sampled between April and September. We used univariate and trivariate analysis of variance and niche region analysis via tridimensional ellipses to investigate possible movement patterns. We found differences in stable isotope ratios between areas, seasons and age classes. Our findings indicate that individuals sampled in Gibraltar, Galicia, Iceland and the Azores may share a common feeding ground in the Northeast Atlantic at different times during the year and that fin whales from the Strait of Gibraltar use this common feeding ground in the summer but exploit Mediterranean resources during the winter months. This further supports the existence of a limited but current exchange of individuals between these two basins though the Strait of Gibraltar.

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A whistle in the model - prediction of bottlenose dolphin presence by an Artificial Neural Network

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Underwater acoustic technologies have provided a useful method for monitoring marine mammal's distribution and habitat use. However, surveys are affected by bias in detection probability. The relation between site specific conditions and the probability of detecting cetaceans has been modeled through Generalized Additive Models (GAM). These models are useful to analyze big datasets that usually contain a surplus of zeros. However, when data is sparse, they tend to over fit easily. Artificial Neural Networks (ANN) are more adaptable to such problems. We propose their use to model bottlenose dolphins (*Tursiops truncatus*) presence in a Mexican coastal lagoon. Two hydrophones were placed at the entrance and the end of a 6 km long channel that connects the lagoon (Ensenada de La Paz) to the adjacent bay (Bahía de La Paz, Baja California Sur). The relationship between dolphin presence (indicated by recorded whistles) and oceanographic and physical variables was modeled with GAMs and ANN. The GAM incorporates six variables and describes 36.0 % of the data. The presence of animals varied mostly as a function of oceanographic variables (tidal height and tidal flow) and lunar forcing (6.5 % and 5.1 %). A three-layer feed-forward network trained through scaled conjugate gradient backpropagation was tested. The network considered nine input variables and predicted 90.4 % of the encounters of bottlenose dolphins correctly, in a balanced set. The most

influent variables might be related to productivity variability due to hydrographic and seasonal conditions, and food accessibility affected by tidal height and direction. Our results highlight the suitability of using ANN to model detection availability for studies of abundance and distribution of dolphins in coastal habitats, essential for conservation purposes.

Uncovering past declines, recent bottlenecks, and historical selection in endangered monk seals

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The Hawaiian monk seal and Mediterranean monk seal are among the world's most endangered marine mammal species, and the only tropical phocid seals. Both species currently have fewer than 1500 individuals each, and their populations have not grown substantially despite extensive conservation efforts in recent decades. In order to find out if the populations of monk seals were much larger in the past, we performed whole genome sequencing on multiple individuals from each species. We analyzed this sequence data using both coalescent modelling and the site frequency spectrum to estimate historical population sizes and the timing of changes in population size. We compared the timing of these trends with the arrival and expansion of human populations in the Hawaiian Islands and the Mediterranean region, as well as with climatic changes. Through this analysis, we found evidence that the populations of both of these endangered species suffered recent and historical declines, suggesting that the populations may have already been vulnerable before any interaction with humans. In addition, we identified genes that showed signs of historical positive selection in these species and explored their relationship with the monk seals' ecological and biological traits. Combined, this work helped shed light on how both historical climate change and interactions with humans have affected the population sizes of endangered monk seals, while also identifying candidate genes that help to explain how phocid seals may have adapted to warmer waters. This research was carried out in collaboration with research teams at Yale University, AMNH, NOAA-PIFSC, MOm, and the University of Barcelona. This new understanding of monk seal population history will be used to inform future conservation efforts by establishing historical baselines for monk seal population recovery.

Stable isotope analysis as a tool to investigate foraging and group dynamics in bottlenose dolphins

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Bottlenose dolphins (*Tursiops truncatus*) are social animals with a network of relationships and varied foraging techniques. A population of approximately 300 dolphins resides near Cedar Key, Florida, most of which are permanent residents. Previous long-term research on this population has documented role specialization, which is unusual in animals that cooperatively hunt. We used stable isotopes of carbon and nitrogen to examine additional questions about the foraging behavior of these dolphins, as these markers are integrated through the diet and reflect foraging habits over an extended time period. Skin biopsy samples were collected from 63 dolphins in 2010. The objectives of our study were to examine potential drivers of this variation including sex, foraging techniques, habitat use, and group dynamics. We found considerable variation in isotopic values among the samples. We found that female dolphins had lower carbon isotopic values than males (2 sample t-test, male mean -17.5, female mean -16.6, p-value = 0.008251). Nitrogen isotope values did not differ significantly with sex. We did not find differences in isotopic values by foraging technique. Ongoing analyses include examining if isotope values vary by group membership and home range size. Stable isotope data can provide more information about the foraging habits of the bottlenose dolphin population in Cedar Key beyond observations from sightings.

Stable isotopic patterns of epidermis structural layers are good indicators for gestation and lactation stages.

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Metabolic needs involved in reproduction are difficult to investigate in free-ranging animals, especially in cetaceans. In this contest, advances in stable isotope approaches allow insights into animal physiology from body tissues collected remotely. Specifically, we hypothesize that the isotopic composition of epidermis structural layers provides $\delta^{13}C$ and $\delta^{15}N$ time series information that

can be used to trace gestation and lactation. We propose that the outermost stratum reflects old metabolic status, while the innermost the most recent ones. To test our assumption, we collected skin biopsies from gray whale lactating females and offspring in Ojo de Liebre breeding lagoon, Mexico, in 2011, 2018 and 2019. Although trends in $\delta^{13}C$ values were not constant between epidermis layers among specimens, $\delta^{15}N$ values differ among skin strata of all organisms. $\delta^{15}N$ values particularly in calves always decreased from the outer to the inner skin strata, most likely due to the assimilation of ^{15}N depleted maternal milk compared to placental blood. We used the nitrogen isotope fractionation of the sampled mother-calf pairs to build a model that predicts calf age and estimates $\delta^{15}N$ values when one of the two couple members is not sampled. Changes in nutritional and ecological conditions can be inferred from the year-to-year differences found between mothers' skin $\delta^{13}C$ and $\delta^{15}N$ patterns. Reproduction status actively affects isotopic patterns and their evaluation appears fundamental to correctly interpret the results of feeding and migratory studies.

Drivers of unique social partitioning in a dolphin social network

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Cetaceans are known for their complex social structure. This structure may lead to behavioural diversity not only among populations, but also within a single population, with different subsets of a population exhibiting different types of behaviour. Understanding the mechanisms of these patterns is interesting biologically, but may also help conservation efforts, because not all segments of a population necessarily respond to, or interact with, human activities in the same way, or at the same time. Such differences may provide insight into the impacts of human activities on wildlife, but also into the evolution of novel behaviours, social learning, adaptation to perturbations in the environment and resilience to anthropogenic stressors. Here, we studied the social network of a resident bottlenose dolphin population over 16 years and found it highly structured into distinct social clusters of mixed sexes. Unexpectedly, the two largest social clusters overlapped spatially, but not temporally, as they used the same area at different times of day and essentially time-shared the same area. Such diel temporal partitioning does not appear to have been documented in any mammals previously. To undertand this temporal and social partitioning, we further investigated several potential drivers of it, including differences in fisheries-related behaviour, diet based on stable isotopes, pollutant levels, and genetic factors. The two clusters differed in ways they interacted with fisheries, as one regularly interacted with trawlers, while the other did not, but this did not explain the temporal partitioning. Stable isotopes indicated differences in diet, particularly differences in trophic level. There were no differences in pollutant loads, with most dolphins exceeding toxicity thresholds, and evidence of maternal offloading of pollutants. Genetic analyses are currently ongoing. This study demonstrates how different segments of animal populations can behave differently, interact differently with human activities and in turn respond differently to anthropogenic impacts.

Quality over quantity: Social bond strength and partner fidelity determine reproductive success in male bottlenose dolphins.

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Reproductive success varies both within and between sexes in most animal species. During the past decade, it has been shown that inter-individual differences in sociality can affect fitness. Most studies have focused on females, while the effects of sociality on male reproductive success are less known. This is, nevertheless, of particular interest since differences in the number of offspring sired can be particularly pronounced in males. Male bottlenose dolphins (*Tursiops aduncus*) in Shark Bay form multi-level nested alliances for the purposes of gaining access to females, these alliances being characterised by strong social bonds lasting up to several decades. Second-order alliances are the core male social unit, within which

subsets of two to three males form 1st-order alliances to consort oestrus females. First-order alliances may differ in stability and composition. Within 2nd-order alliances, social bond strengths vary, with some individuals preferring or avoiding certain other alliance members, whereas other males have no preferences among their alliance partners. We use a combination of genomic and individual-level data on 58 members of seven 2nd-order alliances to investigate whether a male's social network position, home range size, relatedness and age-similarity to alliance partners influence reproductive success. We found compelling evidence that the node strength of social bonds ($p < 0.001$), as well as 1st-order alliance stability ($p = 0.016$), were significant predictors of an individual's number of consortships, a reliable proxy for number of paternities. Individual home range size, relatedness and age similarity to alliance partners, as well as the coefficient of variation in bond strength (used to measure differentiation of social bonds to alliance partners), do not influence access to females. Our results highlight that social bonds, in particular the quality thereof, influence fitness in allied males, thereby adding to our understanding of the conundrum of male cooperation between non-kin.

Clan specific coda playbacks to Caribbean sperm whales.

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Cultural identity creates population structure among both humans and animals by defining social segregation between 'Us' and 'Them'. Sperm whales have a high order social structure which socially segregates hundreds of animals into distinct clans based on vocal dialect. While social communication appears to structure sperm whale society, the functions of these whales' communication signals are still completely speculative; and therefore, how groups of whales recognize each other remains completely unknown. In order to address this knowledge gap, we conducted controlled playbacks of clan-specific coda types with a paired design (Same clan coda vs Different clan coda) to well-known units of sperm whales from both of the sympatric EC1 (1+1+3 coda type is predominant) and EC2 (5R3 coda type is dominant) clans off the island of Dominica. Specifically, we tested the hypothesis that sperm whales cue into coda types for cultural group recognition and respond differently to codas specific to their clan. We completed a total of 7 full playback series. In 4 of those cases, the focal animal was instrumented with a DTag3 sound and movement tag. In all but one playback, the animals did not produce a vocal response to any of the stimuli. In the exception, the focal tagged whale produced a series of characteristic 4D codas in response to the 'same-clan' stimuli. This is particularly interesting as the 4D coda type has been suggested to contain unit level identity cues based on previous analysis. Additionally, generalized linear models indicate that cluster sizes are larger post the entire playback sequence but not necessarily after playback of specific stimuli. This study will serve as the foundation of playbacks experiments like those which have driven the study of birdsong into one of the most productive areas of behavioural ecology.

Ecotourism and cetaceans monitoring in the Pelagie Islands (Strait of Sicily)

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Research ecotourism has a great potential as platform of opportunity for the collection of data on whale or dolphin distribution, habitat use, and long-term photo-identification studies at a frequency that is rarely feasible through directed research. In 2018 Mar.Eco Osservatorio della Natura Association set up a cetaceans monitoring project called "Cetaceans of the islands" in Pelagie Islands, that represent a high biodiversity area for cetaceans in the Mediterranean Sea, and it is supported by tourists participating financing. It aims to provide detailed knowledge of the spatial-temporal distribution and abundance of cetacean species occuring in the surveyed area. In this work are shown the prelinimary results of the monitoring activity carried out during summer 2018.

A total of 51 vessel-based surveys were performed randomly with 125 h of sampling effort and 897 km² covered in the study area. For each sighting, we reported group size, young specimens and associated any species in order to estimate abundance, distribution and use of habitat. The dorsal fin photo-id method was adopted.

A total of 44 sightings of *T. truncatus* were collected, 1 of *Delphinus delphis*, 3 of *Grampus*

griseus, 1 *Stenella coeruleoalba*; 235 individuals were estimated. For *T. truncatus* sigthting frequency is 0.47, the encounter rate is 0.05.

This study is a contribution to assist the regional efforts with scientific knowledge regarding the cetaceans frequentation of the IMMA area of Lampedusa and to foster tourists active participation to environmental and conservation actions throughout the educational element.

30 years of Kogia spp. strandings in South Australia: Distribution, diet and pathology investigations.

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Pygmy and Dwarf Sperm whales, *Kogia* spp., are widely distributed in temperate and tropical waters, yet are among the least understood of cetaceans found in Australian waters. Since 1989, 36 Kogia spp. strandings were documented from the South Australian coast but they were not evenly distributed, with stranding occurring more frequently in the Great Australian Bight. Twenty-eight (15 juveniles, 13 adults) of these form the basis of this study. Post-mortem examinations were conducted on 16 *K. breviceps* and 2 *K. sima,* with meaningful histopathology for 6 animals. Circumstance of death was, 5 live stranded, 1 probable entanglement, 2 possible boat strikes and 10 unknown circumstance. Twelve whales had a robust body condition, two were emaciated and for the remainder, body condition could not be determined due to decomposition. Nematodes and cestodes were recorded in 12 animals. Severe subcutaneous haemorrhaging was found in 12 animals, mostly around head and neck region. Four animals had bone fractures on ribs and vertebrae but the circumstance of death could not be attributed to boat strike. Histopathology results showed mild to moderate interstitial pneumonia in 3 juveniles and mild myocardial degeneration with passive hepatic congestion and pulmonary congestion an adult animal. This heart pathology appeared to have a little similarity with pathology information from other areas of Australia. Eighteen *K. breviceps* stomachs were examined, 13 had hard-part remains of prey (primarily cephalopod beaks and crustacean remains), five stomachs contained nematodes. *Kogia sima* (n=2) stomach contents included cephalopod beaks and nematodes. Dietary information can assist in determining habitat use, foraging behaviour, preferred prey and in assessing direct or indirect interactions with fishery operations. Our study will provide critical baseline information for these species, as well as fill some of the gaps in knowledge for Australian cetaceans.

Sociality and reproductive success of female bottlenose dolphins (Tursiops truncatus) in the St. Johns River, Florida.

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The relationship between sociality and reproductive success (RS) varies among social mammals; high sociality is associated with both positive and negative reproductive effects. Within dolphins, the relationship between female sociality and RS is unclear and complicated by the use of different measures across studies. Thus, we tested this relationship using multiple measures of sociality and RS for bottlenose dolphins in the St. Johns River (SJR), FL. Data were collected via boat-based photo-identification surveys (Mar. 2011–Aug. 2017) and the data set was restricted to females with 5+ sightings (N=87) with calves first sighted as YOYs (newborns; N=179). Sociality measures included each female's number of associates, mean non-zero half-weight index (HWI), maximum non-zero HWI, and mean group size. To account for sample size differences among females, a ratio (number of associates to number of sightings) was calculated. Number of associates and HWIs were calculated using SOCPROG v.2.8. Inter-birth intervals were calculated for subsequent YOYs. RS was quantified as the proportion of calves born during the study that survived through years one (Y1) and three (Y3). Sample sizes varied for each RS measure based on available sighting data. Females' number of associates ranged from 22-212 (mean=129.53±5.25), maximum HWIs from 0.12-0.48 (mean=0.24±0.01), and average group size ranged from 5.80-20.33 (mean=12.46±0.31). Mean inter-birth interval (N=56) was 3.03 years. Overall, 76.52% of calves survived to Y1, whereas 50.63% of calves survived to Y3. On average, females had 1.13±0.07 calves survive to Y1 and 0.62±0.07 calves survive to Y3. Calf survival to Y1 was positively correlated with number of associates ($r=0.23$, $p<0.05$) and negatively correlated with mean HWI ($r=-0.21$, $p<0.05$). Calf survival to Y3 was negatively correlated with maximum HWIs ($r=-0.26$, $p<0.05$) and associates/sightings ratio ($r=-0.12$, $p<0.05$). This pattern may be explained by SJR dolphins' large group sizes, which provide protection for vulnerable calves.

Deep sea prey layer in Cuvier's beaked whale foraging habitat modulated by ocean dynamics

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Cuvier's beaked whale *(Ziphius cavirostris*) is a species of management concern in the Southern California Bight (SCB) due to their sensitivity to navy sonar and the presence of a naval test range in the region. A key component of impact mitigation for pelagic predators such as Cuvier's beaked whale is linking the abundance and distribution of both the predator and their prey to ocean dynamics. However, very few studies have attempted simultaneous measurements of both beaked whales and their prey, in part because of the limited depth range of ship-board active acoustic instruments. The aim of this study was to obtain long-term concurrent measurements of Cuvier's beaked whale echolocation activity, the deep sea prey field, and oceanographic parameters in order to improve our understanding of beaked whale foraging habitat. From March to July 2018, we deployed a mooring with a combination of passive and active acoustic instruments as well as a bottom-mounted Acoustic Doppler Current Profiler (ADCP) in the SCB at Tanner Basin (32° 39.5'N and 119° 28.6'W). Long-term acoustic recordings show that Tanner Basin is an area of intense Cuvier's beaked whale echolocation activity and thus a likely foraging hotspot. Here we report on the 4-month time series of simultaneous prey field measurements and Cuvier's beaked whale echolocation detections. We found a deep scattering layer located between 1040 and 1130 m deep, consistent with Cuvier's beaked whale foraging depth in the SCB. Fluctuations in the backscatter intensity of this scattering layer occurred over multiple temporal scales, most prominently at tidal frequencies, but with large, low-frequency fluctuations over weekly time scales. These fluctuations in the prey field are linked to both the flows interacting with the topography of Tanner Basin and overlying mesoscale flows. It appears that Tanner Basin may focus the Cuvier's beaked whale prey, creating the foraging hotspot.

Spatio-temporal distribution and habitat preferences of cetaceans in the Continental Economic Exclusive Zone of Portugal.

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Cetaceans are key species in marine ecosystems and the knowledge on their distribution patterns is fundamental for the conservation and management of the ocean. In the Portuguese continental waters, 24 species of cetaceans are known, however data on their occurrence are fragmented and scarce. Hence, this work aimed at assessing habitat preferences and the spatio-temporal patterns of distribution for cetacean species in the Portuguese Continental Economic Exclusive Zone. Cetacean occurrence data was collected during summer months (July to October), from 2012 to 2017, within CETUS Project, a monitoring program using platforms of opportunity. About 43258 km were surveyed resulting in 19 cetacean species identified. A total of 962 sightings (686 on-effort) was recorded, totaling an encounter rate of 1,58 sightings per 100 Km. *Delphinus delphis* was the most frequently sighted species followed by *Stenella coeruleoalba*, *Tursiops truncatus* and *Balaenoptera acutorostrata*. Assessment of the preferences for depth, distance to the coast, latitude and longitude was conducted for the most frequently sighted species. Baleen whales' species shared similar latitudes, longitudes and distances to the coast, however, they showed significant differences in depth. Sperm and beaked whales were found in very similar habitats and showed preference for southern latitudes, a fact possibly related to the location of a steep seamount, the Gorringe. The spotted dolphin had preferences for southern latitudes and deep waters. Bottlenose and common dolphins were recorded in habitats significantly different from the other species. Based on the results, priorities for future research were defined: year-round surveys to assess/confirm the degree of occurrence and seasonality of the species, and dedicated surveys in the coastal waters of the North of Portugal and in the Gorringe seamount which seem to be suitable areas for several species.

Pulling the plug on rorqual breathing - and pushing it in for protection at depth.

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The upper respiratory tract of rorquals must be protected against water incursion, particularly when breathing, and against the risk of barotrauma at depth, where air-filled spaces including bony nasal cavities experience high ambient ocean pressures (P_{amb}). The blowhole opening is actively controlled by two types of nasolabial muscles: superficial muscles that form the blowhole margins and paired tubular plug muscles that attach on the rostrum and deep on the nasal septum. The superficial and plug muscles have vastly different morphologies and positions on the skull; we propose they serve different functions. We hypothesize first, that the nasal plug muscles occlude the nasal cavities when not breathing, and second, that they facilitate pressure equilibration between nasal cavities and P_{amb} at depth. We tested these hypotheses by observing rostrum and blowhole morphology with drones and animal cameras. We dissected adult and fetal fin whales to assess tissue morphology and physically manipulate the plugs. Muscle morphology in-situ was obtained from an MRI scan of a minke whale fetus. We found each nasal plug had three histologically distinct regions: a muscular rostral region, a predominantly fatty mid-section at the blowhole, and an elastic tendon that attached the plug caudally, deep within the nasal cavity. We propose muscle activation while surfacing pulls the fatty section rostrally, opening the nasal cavities to air, while the elastic tendons snap the plugs back into place to seal the nasal cavities after breathing. At depth, we propose P_{amb} pushes the fatty region further into the nasal cavities, and calculate this could reduce the air volume of the nasal cavities by half. Such movement would equilibrate nasal cavity pressures with P_{amb} between lung collapse depth (~100-150m) and lower feeding depths (~200-300m). We conclude adaptations of nasal plug structure may provide a crucial mechanism to adjust nasal cavity volume to P_{amb}.

Modernizing Canada's approach to North Atlantic Right Whale management: Lessons learned and future challenges.

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Since 2016, the Government of Canada has made significant new investments through the Oceans Protection Plan, the Whales Initiative and the Nature Legacy, to advance the recovery of aquatic at-risk species, with a particular focus on endangered whales including the North Atlantic Right Whale (NARW). We present a case study analyzing the evolution of the Department of Fisheries and Oceans' adaptive management approach to mitigating key threats to this species, including fisheries interactions and vessel disturbance. These include both harm-reduction and preventative measures, such as static and dynamic closures in fisheries to reduce the risk of fishing gear entanglement for NARW, minimum vessel approach distances for cetaceans including NARW under the amended *Marine Mammal Regulations*, mandatory reporting of lost gear and marine mammal interactions in fisheries, and key investments to support gear innovation. Since significant targeted actions were taken following the NARW Unusual Mortality Event of 2017, there are some early signs of success, including no reported NARW deaths in Canadian fisheries waters in 2018. Key challenges to modernizing whale management include addressing regulatory hurdles, obtaining industry buy-in for measures, managing stakeholder expectations, and navigating scientific uncertainty. As the Department moves forward implementing an iterative harm-prevention approach to whale management, engaging Indigenous partners, stakeholders and the international community will be critical to the continued evolution of science-informed management measures that will help to achieve transboundary species recovery. The Department will build on this NARW management regime by improving existing measures and evaluating new approaches to support the recovery of these endangered whale species while considering socio-economic impacts to industry and coastal communities.

Prevalence of fishery-related scarring on the mouthlines of common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands

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Fisheries interactions pose a serious threat to the conservation of many species of marine mammals. It is often difficult to directly observe and record these interactions, and many fisheries lack observer programs. Around the main Hawaiian Islands, multiple species of cetaceans have been documented interacting with both recreational and commercial fisheries, including common bottlenose dolphins, which have been observed depredating bait or catch from hook and line fisheries. To better assess non-lethal interactions between bottlenose dolphins and fisheries, photographs from a long-term (1987-2018) photo-ID catalog were examined for wounds or scarring that may have resulted from hooking or entanglement with fishing gear. The sample included known males and females and all age groups. Assessments included individuals from all four island-associated stocks among the main Hawaiian Islands. Photographs were examined showing mouthlines where hookings are most likely to occur. Individuals with mouthline scarring were also assessed for injuries on the leading edge of the dorsal fin and the head and/or peduncle, which may be damaged when individuals are hooked and struggle against gear. In total, photographs of 610 individually identified bottlenose dolphins were examined. Mouthline injuries consistent with fishery interactions were only found on adults. Analyses restricted to adults with ≥50% of the mouthline visible (n=432) revealed 14 (3.2%) with injuries consistent with fishery interactions, including 13 with mouthline injuries and one with a dorsal fin injury. Some individuals had additional evidence of line wraps on the head or peduncle. Individuals with such injuries were found from all four insular stocks, but were most prevalent from the Hawai‘i Island stock. These results provide evidence that non-lethal injuries from fisheries do occur in bottlenose dolphin populations around the main Hawaiian Islands. Additional research is needed to assess the significance of these results on a stock-by-stock basis in Hawai‘i.

Seals from space: Identifying change in Antarctic ecosystems via the monitoring of ice-seals and sea ice habitats by very high-resolution satellite and UAV imagery.

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Antarctic pack-ice seals (APIS) are long-lived, upper trophic level predators and amongst the largest consumers of Antarctic krill. Therefore, the monitoring of APIS populations can indicate changes in the Antarctic ecosystem. However, APIS inhabit the inaccessible sea ice zone, making traditional surveys (plane/boat) logistically difficult. Because of these challenges, reliable population estimates and habitat information for ice-seals are lacking. To overcome these limitations, *very high-resolution (VHR) satellite* and *unmanned aerial vehicle (UAV)* imagery will be used to detect/discriminate ice seal species for counts at local scales and identify habitat hotspots at broad regional scales. This involves identifying species classification parameters; extracting sea ice characteristics; constructing *habitat models* to explain population dynamics and predict responses to environmental change.

Satellite surveys have been conducted on breeding seals to test various classification techniques due to their increased haul-out duration. The accuracy of each technique will be assessed using thermal/optical data sourced from ground-truthing UAV surveys to exclude artefacts and determine count variance. Resulting insights into the distribution and habitat preference of seal colonies will inform the automated detection of *habitat hotspots* for present and future sea-ice conditions under a range of climate scenarios, the development of a penguin-seal-fisheries competition index and the first robust pan-Antarctic ice-seal population estimates. Shifts in habitat extent/competition determined from these data will inform IUCN red list assessments. Given that sea ice volume is predicted to decline significantly by the end of the century, the monitoring of ice-seals and their habitat via VHR imagery is pivotal to *polar marine conservation*. Here, we present details of the satellite/aerial surveys conducted on breeding ice seals, and the on-going development of *machine learning algorithms* to provide the first VHR sea ice classification techniques. We will also discuss the capacity for dynamic conservation management provided by an automated system for near real-time habitat mapping.

Winter distribution of endangered belugas in Cook Inlet, Alaska

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Cook Inlet belugas (CIB) were listed as endangered in 2008 with a recovery plan finalized in 2016. The CIB is also one of NOAA's Species in the Spotlight; an effort to save the most highly at-risk marine species. In 2018, NOAA and the Bureau of Ocean Energy Management (BOEM), undertook a multi-year project to document the winter distribution of CIB using aerial surveys. Long-term NOAA surveys show the summer range of CIB has contracted to areas of upper Cook Inlet (UCI). However, CIB winter distribution is not nearly as well documented. The last winter surveys and satellite-tagging studies occurred in 2002. With concerns that CIB may be adversely affected by increasing development in lower Cook Inlet (LCI) a broader picture of distribution is needed. In 2018, we began winter shoreline surveys and sawtooth transects throughout Cook Inlet. Survey sightings showed belugas in both UCI and LCI. A relatively ice-free November 2018 survey recorded belugas only in UCI. Notable LCI beluga sightings occurred in Tuxedni Bay March 2018 and 2019. Previous studies have also documented beluga presence in Tuxedni in March where whales may be taking advantage of spring herring runs. March sightings near Kalgin Island (LCI) may also coincide with a herring run. Belugas were also observed in the Kenai River (LCI) in March. Historically Kenai has been an important foraging location year round but a dramatic increase in human activity may be contributing to belugas utilizing the river only during the 'off" season. Although our initial results show belugas utilizing LCI in the winter, their winter range still appears more contracted compared to the range in the 1970s,. Additionally, CIB are now remaining in UCI waters year round. Winter range information is important to take into consideration as oil and gas exploration expands in this increasingly ice-free and accessible environment.

Current review of Pacific blue whale (Balaenoptera musculus) populations
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Blue whales in the eastern North Pacific (ENP) migrate in summer/fall from Mexican and Central American waters to coastal feeding areas off of the west coast of North America (from Baja California to the Gulf of Alaska). An aerial photogrammetric analysis of ENP blue whales indicates that they are similar in total length (TL), tail length and rostral length to the pygmy blue whale (*Balaenoptera musculus brevicauda*) described from the Indian Ocean. Blue whales taken in fisheries along the Aleutian Islands were likely a separate Central No. Pacific population (based on TL data and acoustics) while blues taken in the Sea of Japan comprised a Western No.Pacific population that is likely extirpated.

A recent publication concluded that blue whales found during winter and early spring in the Gulf of California are morphologically different from the described ENP blue whales. This was based on tail lengths derived proportionally (as no TL data were available). The paper suggests, based on a recent genetics study, that Gulf of California blue whales may in fact be migrants from the southern hemisphere.

In response to this publication, in this presentation, morphometric data for ENP blue whales (derived from aerial photogrammetry and fishery data) were stratified geographically and graphically presented. Results indicate that ENP blue whales sampled at different latitudes along the Pacific are similar in external morphology (albeit sample size was small for some locations such as the Costa Rican Dome). Furthermore, the likelihood of a blue whale population in the Gulf of California that is separate from the ENP population will be discussed based on current and historical information. The relationship between eastern South Pacific (ESP) and ENP blue whales will also be discussed.

Revisiting Natura 2000 network from a Systematic Conservation Planning perspective: The endangered Mediterranean common dolphin subpopulation as a case study.
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Several European conventions and agreements propose the establishment of marine protected areas (MPA) for cetacean as one of the available tools to preserve populations and their habitats. This area-based protection has been mainly driven by the

implementation of the Natura 2000 network of MPAs under the Habitat Directive (92/43/EEC). Only bottlenose dolphins and harbour porpoise are listed as cetaceans species that deserve the establishment of special areas of conservation. Nevertheless, other species such as the Mediterranean common dolphins should benefit of area-based protection to face their main threats. Here, we evaluate if the Natura 2000 network is protecting the common dolphins in the Alboran Sea through a systematic conservation approach. Furthermore, we use this endangered species as a case scenario to understand how the addition of fisheries information may influence the conservation planning output. Overall, our results suggest that the current MPA network largely overlap with the "core areas" for this population protecting 22% of its abundance. However some important gaps in conservation planning are detected at the western side of their distribution. Further, offshore areas are also systematically selected as important areas for common dolphin conservation when fishing effort is included as a cost for conservation. This is because fishing effort at such offshore areas is very low compared to that within main "core areas" for dolphins distribution, so they are "cheaper" to protect. However, these areas represent the marginal distribution of the species and their protection may have undesirable ecological consequences such as the conservation of potentially low quality individuals while harmful interactions would continue in the main "core areas". Owing to the spatial congruence between dolphins and fisheries' distribution, effective conservation actions will certainly have costs on this essential supporting service. Then conservation decision-makers must achieve a trade-off between cetacean conservation and fisheries.

Inferring animal social networks with imperfect detection.

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Social network analysis provides a powerful tool for understanding social organisation of animals. However, in free-ranging populations, it is almost impossible to monitor exhaustively the individuals of a population and to track their associations. Ignoring the issue of imperfect and possibly heterogeneous individual detection can lead to substantial bias in standard network measures. Here, we develop capture-recapture models to analyse network data while accounting for imperfect and heterogeneous detection. We carry out a simulation study to validate our approach. In addition, we show how the visualisation of networks and the calculation of standard metrics can account for detection probabilities. The method is illustrated with data from a population of Commerson's dolphin (*Cephalorhynchus commersonii*) in Patagonia Argentina. Our approach provides a step towards a general statistical framework for the analysis of social networks of wild animal populations.

Environmental factors driving short-beaked common dolphin coastal distribution and habitat suitability in NW Spain.

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Marine ecosystems, especially those located in coastal areas are heavily affected by human activities. Research conducted in these areas should be aimed at improving the conservation of threatened species and habitats. Environmental factors have been used to understand species distribution and the latter has proven to be a fundamental tool to promote effective conservation measures and management plans. The present work explores the use of species distribution models like the Environmental Niche Factor Analysis (ENFA) to assess the habitat suitability of common dolphins (*Delphinus delphis*) in Northwest Spain, and its application to the development of effective conservation and management measures. Although recent studies on the distribution of the species in Atlantic waters show that the Northwest Iberian Peninsula is an important area for common dolphins, there is a lack of information on the ecological niche and the spatial distribution of the species in coastal areas. Presence-only data was linked to ecogeographical variables (EGV) to assess the potential distribution of the species. Data were collected during 273 days at sea, covering a total distance of 9 417 km between March 2014 and October 2017 with a total of 91 common dolphin encounters. The study reveals that tide level and sea surface salinity are the main EGVs driving common dolphin distribution in coastal areas. Furthermore, the study shows that fisheries might have an

impact on the species distribution as they exert an intense pressure in areas that include the most suitable habitat for common dolphins. Findings of this study contribute to a more comprehensive understanding of common dolphin coastal distribution and highlight the importance of species distribution models in the development of effective conservation and management strategies.

Geographical variation of piebaldism in Black Sea bottlenose dolphins

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Natural elements of anomalous white hair or skin coloration are observed in many animals. These elements can be either small patches lacking pigmentation (piebaldism) or fully depigmented body surface. Such cases are relatively rare among cetaceans. Here we present the first report on one fully white and several piebald bottlenose dolphins *Tursiops truncatus* (Montagu, 1821) in the Black Sea.

In result of photo-identification of bottlenose dolphins covering all the coastal areas of the Black Sea and the Bosphorus Strait (n=751), piebald animals (n=30) have been recorded in most of areas, and a fully white dolphin has been observed in the north-eastern Black Sea between 2007 and 2013. Also, the greatest concentration of piebald dolphins was found in the north-eastern areas (Sudak, 13%, and Balaklava, 9%), significantly more than in the other areas. The lesser percentage was in the Bosphorus Strait (4%), and only few sightings have been reported from the north-western and eastern Black Sea. Cases of piebaldism were not recorded in the southern Black Sea. Therefore, there is a gradient in geographic distribution of piebaldism in the Black Sea bottlenose dolphins with the maximum in the north-eastern area. In most cases, the white patches were located on the dorsal fin: they were small, of irregular shape, often nearly symmetrical at the left and right sides. In some cases there were white patches on the dorsal side of the body or peduncle, on tail flukes. This kind of coloration can be caused by several mutations or metabolic mechanisms. Meanwhile, frequent occurrence of piebald animals in local populations can be explained by gene drift, founder effect and/or inbreeding. This could be an evidence for population divergence.

Establishing skin cell cultures in gray whales to examine their sensitivity to marine contaminants (PAHs, PFCs, PCBs, oil).

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The gray whale (*Eschrichtius robustus*) often travels and feeds close to dense coastal human populations. Marine contaminants including polycyclic aromatic hydrocarbons (PAHs) (incomplete combustion products), per/poly-fluorinated compounds (PFCs) (industrial products with anti-stick and flame-retardant properties) and polychlorinated biphenyls (PCBs) (historically produced as electrical insulators), have been detected in cetacean blubber. Crude oil is released in the marine environment from both anthropogenic activities and natural sources. Little data exists on the effects of these contaminants in *E. robustus*. Our aim is to understand whether organic pollutants are cytotoxic in gray whale tissue and whether these toxicants are of concern for the species. Cell culture is invaluable in research involving protected species as it is minimally invasive and allows for multiple investigations using a single biopsy. We cultured primary fibroblasts that were propagated from skin biopsies obtained from three free-swimming eastern gray whales. Cells were maintained in DMEM/F12 media supplemented with 15% cosmic calf serum, 1% glutamax, 1% penicillin/streptomycin, and 0.1% sodium pyruvate. Cultures were incubated in a humidified atmosphere of 5% CO_2 at 37°C. Cytotoxicity was measured via MTT (methylthiazolyldiphenyl-tetrazolium bromide) and LDH (lactate dehydrogenase) assays. Toxicants selected were media accommodated fractions of crude oil and/or Corexit (an oil dispersant) or benzo[a]pyrene (B[a]P) or PCB 126 in

concentrations of 10µM, 1µM, 0.1µM, or 0.01µM or perfluorooctanoic acid (PFOA) in concentrations of 500µM, 50µM, 5µM, 0.5 µM, or 0.05µM. Exposure time points were 24h, 48h, 72h, and 96h for each toxicant. Cytotoxicity was measured colorimetrically via spectrophotometer. Cellular viability was significantly reduced after exposure to B[a]P, PCB 126, and PFOA at various concentrations and time points ($p<0.05$). Additionally, cellular viability was significantly reduced after exposure to B[a]P at environmentally relevant concentrations. Preliminary results suggest that cellular viability was reduced after exposure to Corexit. Further investigation is currently underway.

Fatty acid content of Pacific walrus (Odobemus rosmarus divergens) skeletal muscle lipids.

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Pacific walrus foraging success depends on both prey biomass and the proximity of foraging areas to haulout sites. Reduced summer sea ice availability constrains walrus habitat to secondary coastal haulout sites, which may deplete prey at those locations. Female and juvenile walruses are at an increased risk of nutritional stress, requiring shallow, densely aggregated prey to efficiently forage within their shorter aerobic dive limits, while meeting the additional energetic costs of growth and reproduction. Females nurse and forage with their calves almost continuously, giving birth to the next calf shortly after weaning the previous calf. Stored lipids are an important resource for offsetting the increased reproductive costs of lactation and pregnancy, and during periods of limited foraging. Pinnipeds preferentially metabolize polyunsaturated fatty acids (PUFA) because they require less oxygen to convert into ATP. Fatty acids were extracted and analyzed from Pacific walrus skeletal muscle samples obtained through Native subsistence harvests during spring in Alaska between 2009 – 2015 (n = 50). Muscle saturated fatty acids (SFA), at an average of 73% of total lipids, were more than twice concentrations previously noted in walrus blubber or muscle lipids analyzed in phocids. The range in SFA proportions differed between males and females, with males ranging between 33% and 88%, while females only differed between 71% and 89%. Spring walrus migration from southern to northern habitat, as well as pupping, have the potential to limit foraging in males and females and increase the reliance on stored lipids for fuel. The high proportion of SFAs in walrus skeletal muscle may indicate that the animals have exhausted the available PUFAs and MUFAs in blubber stores and have switched to mobilizing SFAs. This potentially indicates that a higher proportion of males are actively foraging during migration, while females are entirely reliant on stored lipids.

Adapting to climate change: Trends in Weddell seal abundance over two decades.

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Climate change has significantly impacted coastal marine ecosystems of Antarctica. In the last several decades, the western Antarctic Peninsula (wAP) has experienced massive ice losses, represented by glacier retreat, ice-shelf collapses and sea-ice reduction. The surrounding waters of the South Shetland Islands (SSI), a major archipelago of the wAP, are now ice-free year-round in most years. The Weddell seal (WS) has a circumpolar distribution and is an abundant predator in coastal areas of the SSI. The pagophilic nature of WS has led some to predict that loss of sea ice will adversely affect this species. Here, we examined 20 years (1997-2016) of weekly census data(November –February) for Cape Shirreff, Livingston Islandlocated in the SSI. We tested the hypothesis that the regional presence of off-shore ice and WS preference for ice results in fewer numbers hauled out on land. Contrary to predictions, there was no indication that regional offshore ice affected on-shore abundance. Furthermore, our results indicate a stable to increasing abundance of Weddell seals on land at Cape Shirreff. Despite a preference for near-shore ice, this species appears toadapt well to breeding and foraging in ice-free habitat.

Fish legacy or evolutionary novelty: Hitherto unknown bones reflect evolutionary heterochronies in cetacean skull.

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The cetacean skull is characterized by delayed and incomplete postnatal ossification of skull sutures. Also, there are a few additional non-typical bones and clefts appearing in the skull vault and temporal region of various cetaceans, both mysticetes and odontocetes. Some of them can be interpreted as

Wormian bones; however, others are large and not located within the cranial sutures. These ossification centers can be identified or interpreted as postparietal, tabular, lateral extrascapular, posttemporal and supratemporal bones, and, therefore, they can be classified as atavisms typically lost in mammals but existing in early reptiles, amphibians or even sarcopterygian fishes and the earliest tetrapods. Also, two ossification centers were found for the parietal bone, confirming its dual origin in amniotes. Slowing development rate well explains these phenomena, and, therefore, non-typical features of cetacean skulls, whether they are atavistic or novel, are interpreted as a result of paedomorphosis. The possible function of delayed skull ontogenetic development is the prolonged development of the braincase, temporal region and the upper jaw, as well as the skull kinetism for suction and gulp feeding.

Crimean coast of the Kerch Strait: Original evidences about cetaceans.

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Straits are very important in cetacean life cycle; the Kerch Strait (KS) as unique passage between Sea of Azov and Black Sea is among them. A length of KS Crimean coast between Khroni and Takyl Capes is 42.7–45.0 km. KS and adjoining area are the sites of highest fish diversity and resources concentration in the basin. Meanwhile, it is arena of rising anthropogenic pressure on marine environment, especially during last time. Cetaceans, mainly bottlenose dolphins (TT) and harbor porpoises (PP), occur in KS all year round (85.4% in summer), except of season of extremely hard ice conditions in KS and the Sea of Azov; and it is very interesting ecosystem for investigations. The analyzed materials were obtained from information of about 4000 students, local people, sailors and fishermen in 2002–18 (153 of respondents are residents of Kerch Peninsula); 200 sightings (TT – 34.0%, common dolphins (DD) – 17.9%, and PP – 48.1% of identified cases) and 75 strandings (TT – 20.5%, DD – 12.8%, and PP – 66.7% of identified cases) were reported. Crimean KS coast was divided into three sectors: North (Azov) – Yeni Kale Light House, Kerch ferry boat, Borzovka, and Kapkany; Center (Kerch) –Tuzla Spit, Kerch Bay and beaches, Arshintsevo, and El Tiygen; and South (Black Sea) – Tobechik and Takyl Cape. Some differences in cetacean taxonomic structure were distinguished: in the North and Center PP dominated in sightings/strandings – 68.2/55.6%, and 46.3/74.1%, but in the South balance between TT (50.0/33.3%) and PP (50.0/66.7%) was another. The most of sightings observed in Kerch ferry boat (10.0%), Kerch Bay (49.0%), and El Tiygen (12.0%). Strandings were discovered in Azov coastline (9.2%), Kerch Bay (58.5%), Yeni Kale Light House and El Tiygen (in 6.2%). The annual peaks of cetacean occurrence were in 2008 (23.0%), 2003 and 2012 (in 7.5%).

Phocine distemper outbreak in phocid seals off the United States east coast in 2018-2019.

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An Unusual Mortality Event (UME) was declared by the National Marine Fisheries Service on August 30, 2018 due to increased numbers of harbor seal (*Phoca vitulina*) and gray seal (*Halichoerus grypus*) strandings along the U.S. coasts of Maine, New Hampshire, and Massachusetts during July and August. In January 2019 harp (*Pagophilus groenlandicus*) and hooded (*Cystophora cristata*) seals also began stranding as they migrated from Canada into U.S. waters. Strandings remained elevated and have expanded to include nine states from Maine to Virginia with over 2000 seals stranding since July 2018. Live seals had evidence of respiratory and/or neurological disease, with pneumonia present on gross necropsy examination. Histologically, seals had bronchointerstial and/or suppurative pneumonia, meningoencephalitis or encephalitis, and/or lymphoid depletion consistent with morbillivirus infection. Tissue or swab samples from ~65% of harbor and gray seals tested by polymerase chain reaction (PCR) were positive for phocine distemper virus (PDV). No harp or hooded seals have tested positive to date. Additionally, ~86% of harbor and gray seal cases tested by immunohistochemistry (IHC) were positive for PDV in lung, lymph node or brain tissue. Serum from a subset of seals tested had PDV neutralizing antibodies, with titers ranging from 1:64 to > 1:512. Virus isolation and genome sequencing of the virus from this outbreak determined the sequences to be most similar to the 1988 and 2006 PDV isolates. Naïve live seals in rehabilitation are being vaccinated with the PUREVAX® ferret distemper vaccine prior to release to ensure protection and improve survival after release. The potential impact of this outbreak on phocid seal population(s) off the US east coast is being monitored.

Assessment of sublethal cardiac injury in bottlenose dolphins (Tursiops truncatus) in the Gulf of Mexico following exposure to deepwater horizon oil-associated chemicals

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Health studies conducted in the wake of the *Deepwater Horizon* (DWH) disaster represented significant progress in characterizing oil-associated effects on cetaceans; however, some critical questions remained unanswered. In 2016, an increased prevalence of systolic heart murmurs was noted in dolphins from heavily-impacted Barataria Bay, LA (BB) relative to those in Sarasota Bay, FL (SB), outside the oil spill footprint. Due to limited cardiac diagnostics in field protocols, the effects of oil on cardiac health had not been fully evaluated. To address this need, innovative field-ready techniques for cardiac evaluation were developed with U.S. Navy dolphins and then applied to live BB and SB dolphins during comprehensive health assessments in 2017 and 2018. Systematic cardiac auscultation detected fixed or dynamic murmurs in the majority of animals regardless of oil-exposure history; most murmurs (95%) were due to benign elevation of velocity of flow through one or both cardiac outflow tracts. Telemetric 6-lead electrocardiography detected arrhythmias in more BB dolphins (43%) than in SB dolphins (29%), with all animals having an underlying normal sinus arrhythmia. Arrhythmias were considered low to moderate risk for adverse cardiac events and included atrial and ventricular premature beats, sinus tachycardia, and 2nd degree atrioventricular block. Echocardiography showed the mean interventricular septal wall (IVS) thickness was less

(p=0.0031) in adult BB males (meanIVS = 0.32 cm + 0.05 SD) compared to adult SB males (meanIVS = 0.42 cm + 0.07 SD), however, whether this difference is an indication of cardiac disease or physiologic differences is not known at this time. Potential mechanisms for cardiac injury were evaluated by retrospectively examining histologic lesions in tissues of dead, stranded dolphins. On histologic evaluation, dolphins within the oil spill footprint had a higher prevalence of cardiac fibrosis than control animals stranding outside the spill area (44% vs 19%, p=0.002).

"Whales from The Hill": A platform for studying humpback whales in the northeast of Brazil.

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The humpback whales from the breeding stock A are recovering and currently, the whales are observed throughout northeastern Brazil. Since 2014, monitoring studies of humpbacks have begun in Serra Grande, a region where the continental shelf is narrower in the Brazilian coast, allowing the whales to approach near the coast. Land-based visual monitoring using a total station, and passive acoustic monitoring using Oceanpods deployed on the seabed at a sampling rate up to 16 kHz were conducted between July and October in 2014, 2015 and 2018. The objective of this project is to use these platforms with unique characteristics to monitor humpback whales, evaluating habitat use and movement patterns, as well as the evolution of acoustic communication of this population. The number of individuals observed at the peak of the seasons has increased over the years, with a maximum of 21 individuals observed per hour. Most of the groups observed were in waters of less than 50 m depth. The movement patterns, as net speed (5.49±2.73 km/h) and linearity (0.81±0.18), have remained constant over the years. Singing was the predominant vocal activity, but at least 13 social calls were also detected. Ten song themes were described: four themes were maintained between 2014 and 2015, and only one between 2015 and 2018. The next steps are the description of the repertoire of social sounds of this population and the study of song evolution applying the Levenshtein Similarity Index. Intra- and inter-population song comparisons are also planned within a newly formed research network in Latin America. The continuity of these monitoring efforts in the long term will allow us to identify the population and behavioral trends of the breeding stock A, building a baseline database about humpback whales before the construction of the new Port complex in the vicinity of Serra Grande area.

Comparison in phthalates concentration in four species of whales with different feeding behaviour from Mexican Pacific

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Over last decades, plastics litter have become a major problem due to its persistence and widespread distribution in the marine environment. Smaller fragments derived through environmental degradation from larger plastic can be easily incorporated in food chain, particularly microplastics (MPs), <5mm particles, that are ingested mistakenly by marine organisms and may cause long-term adverse effect as transfer and accumulate associated toxic chemicals into animal tissues. Phthalate esters (PAEs) are plasticizers that induce endocrine toxicity may have sublethal effects in hormone synthesis and, alter reproduction or other physiological and metabolic functions. The principal objective of the present study is to determine the concentration of PAEs in four whale species with economic, social and environmental importance to mexican community (*Balaenoptera physalus*, *B. musculus*, *Eschrichtius robustus* and *Megaptera novaeangliae*). To this aim, biopsies has been collectedin the whale feeding and breeding

grounds areas: San Ignacio Lagoon (gray whale: 5 males and 5 females), Los Cabos (humpback whale: 10 males) and Gulf of California (fin whale: 17 males). In addition, 8 zooplankton/MPs samples will be taken from two areas of the Gulf of California (Bahía de Kino and San Luis Gonzaga). In respect to PAEs, five diesters and their main monoester metabolites will be detected (DEHP, MEHP, DIOP, MIOP, BBzP, MBzP, DBP, MBP and DiBP, MiBP) using the GC-MS technique. Profiles of these chemical compounds in blubber will serve as plastic tracer of MPs and to assess whether the variation in feeding areas and habitats is reflected in their PAEs levels. Moreover, zooplankton/MPs samples will allow information about the ingestion/exposure to MPs and contaminated prey that affects two feeding grounds of whales in the Gulf of California.

Temporal distribution and multi-scale habitat preference analyses for Azorean blue whales

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Blue whales are sighted every year around the Azores islands, which apparently provide an important seasonal foraging area. In this study we aim to characterize habitat preferences and analyse the temporal distribution of blue whales around São Miguel Island. To do so, we applied Generalized Additive Models to a seven-year opportunistic cetacean occurrence dataset (2008-2014) and remotely sensed environmental data on bathymetry, sea surface temperature, chlorophyll concentration and altimetry (MSLA). Oceanographic dynamism in the Azores has been recently studied at a regional scale. However, detailed information at a more local scale is still scarce. As our study area is well limited and relatively small, here we provide a high-resolution description of the oceanographic conditions around São Miguel Island based on the environmental variables previously cited. We emphasize its high spatio-temporal variability. In order to capture this dynamism, we used environmental data with two different spatial resolutions (low and high) and three different temporal resolutions (daily, weekly and monthly), thus accounting for both long-term oceanographic events such as the spring bloom, and shorter-term features such as eddies or fronts. Blue whales' temporal distribution was analysed for sightings recorded between 2008 and 2018, accounting for a total of 188 records. Interannual differences in the number of blue whale sightings are apparent. Our results show that blue whales have a well-defined ecological niche around the Azores. They usually cross the archipelago from March to June, every year, and habitat suitability is highest in dynamic areas (with high Eddy Kinetic Energy) characterized by convergence or aggregation zones where productivity is enhanced. Multi-scale studies are useful to understand the ecological niche and habitat requirements of highly mobile species that can easily react to short-term changes in the environment.

Female productivity and calf survivorship of bottlenose dolphins (Tursiops truncatus) in Bocas, Panama

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The resident bottlenose dolphins of the Archipelago of Bocas del Toro are regularly exposed to intense interactions with dolphin-watching boats. Despite these intense interactions, the dolphins remain in the area for two reasons: the bay's safety from predators and abundance in food resources. However, ongoing studies indicate that while the preferred food source, sardines, is abundant, they provide low caloric gain. This means that the dolphins must eat regularly. Previous research has shown that Bocas dolphin foraging behavior is disrupted throughout the day by tour boats. This has created concerns about the health of the population, particularly lactating mothers and the potential effects on calf survival. In this study, we used mark-recapture data from 2004 to 2015 to infer dolphin female reproductivity and calf mortality rates. A total of 35 females were identified from 140 dolphins in the current catalog. Twenty-three of these females are regular users of Dolphin Bay. The bay is part of their home range where they regularly interact with dolphin watching boats. Each female in this population had between one and three calves during the study period, with

an average calving cycle of 62 months (SD: 21.91 months**,** Range: 24-97 months), longer than other known populations. Furthermore, calf mortality was estimated to be 0.46, which is higher than reported for other bottlenose dolphin populations. The survival rate for this population is estimated to be 0.54. Understanding female reproductive success in this local population of dolphins may provide a quantifiable measure of health and individual fitness, which are essential to protect this population.

Characterization of side scan-sonar images produced by Amazonian River dolphins (Inia geoffrensis) to reduce potential confusion during surveys of Amazonian manatees (Trichechus inunguis).

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Side-scan sonar (SSS) has been successfully used to detect West Indian and African manatees, however confirmed sonar images of Amazonian manatees have not been obtained yet. One potential difficulty is differentiating manatee images from other large aquatic vertebrates. The Amazonian manatee shares most of its habitat with two cetaceans, the Amazonian River dolphin (ARD, *Inia* spp.) and the Tucuxi (*Sotalia fluviatilis*). In this study we characterize the sonar image produced by the ARD and make notes on behavior observed during surveys for Amazonian manatees. Boat surveys using SSS were conducted during the high (July 15-30, 2017 and March 17-21, 2019) and low (December 13-21, 2017) water seasons in Amanã Lake, Amanã Sustainable Development Reserve, Amazonas, Brazil. Sonar surveys were recorded and then analyzed with ReefMaster Sonar Viewer (v. 1.0.36). Unlike the acoustic images produced by manatees, ARD acoustic images contain sharper angles and narrower shadows. At slow speeds (1-3 km/h), the shadow resembles an ARD, with a low profile dorsal fin, a narrow beak, and a narrow tail with a fluke. At faster speeds (4-5 km/h), the acoustic image can be elongated with a wavy tail due to the ARD swimming alongside the boat. ARD in Lake Amanã repeatedly followed our boat for kilometers during several hours, swam under the boat and approached the SSS transducer, suggesting they could hear the sonar, but were not distressed by it. ARD were usually seen in small pods (1-4), however several pods would aggregate over time in relatively large numbers (10-20) around the boat. In conclusion, ARD acoustic images have unique characteristics and can be reliably distinguished from known manatee acoustic images, however due to the behavior of ARD and their propensity to approach survey boats, care must be taken when surveying for Amazonian manatees.

Environmental determinants of habitat use by Caspian seals (Pusa caspica) and implications for marine conservation planning

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Here we describe a multi-year satellite telemetry study of Caspian seals spanning 2009-2017, involving 111 tag deployments, with active periods of up to 11 months. We apply state-space models to characterise tracks into 'area restricted search' (ARS, which may be indicative of foraging activity), and travelling behavioural states, and examine how environmental variables including sea surface temperature, bathymetry, bathymetry slope, distance from shore, bottom sediment type, and vessel traffic density affect the probability of ARS in summer and autumn seasons. We use General Additive Models to generate predictions for ARS habitat usage by Caspian seals across the Caspian Sea, and then evaluate overlap with human activities and the implications for potential marine protected area locations.

In the best fit models, all the environmental variables explained significant variation in ARS probability. Predicted ARS probabilities were highest in offshore areas with sloping bathymetry around the edges of the Caspian mid and southern basins, and lower in areas with water depths exceeding 400m, or with mean sea surface temperature less than 22ºC. Data from 2011 was used to generate a baseline model, and data from the 2016 deployment to validate model predictions. The original model successfully predicted ARS hot spots in the 2016 data, suggesting it adequately describes environmental factors influencing seal ARS distributions, and that there is consistency in patterns of habitat usage across years. Locations

with the highest predicted importance for ARS may be candidates for future marine protected areas to safeguard seal feeding habitat.

Human activities, including offshore industrial developments and regions with high vessel traffic density overlap with many areas with high ARS probability. Evaluating potential impacts from intensive human use of the Caspian offshore environment therefore needs to be given high priority when planning industrial activity in these zones.

Humpback whale calls detected by autonomous Wave Glider in tropical ocean basin between known Hawaii and Mexico breeding assemblies.

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Humpback whale behavior and distribution have been relatively well studied in near-shore locations but far less explored in deep ocean basins, where access is limited or expensive. In recent years several autonomous robotic vehicles have been developed and tested for deep sea research including the passive acoustic monitoring of cetaceans. In this study a Wave Glider known for its success in long transits of offshore waters was fitted with a hydrophone system to record humpback whale calls. North Pacific humpback whales' summer in feeding grounds on continental shelves around the Pacific Rim from California to Japan, and, in winter, migrate southwards across deep seas to several traditional tropical breeding grounds – two of these are the Mexican mainland coast and offshore islands (Revillagigedo Islands), and the Hawaiian Islands. These Mexico and Hawaii winter assemblies have recently been assessed by US NMFS as distinct population units warranting separate management (and different protective status). However, their shared song composition indicating mixing and interchange of photo-identified whales complicates this assessment. To investigate any winter connection between these assemblies, the Wave Glider performed a 3,761.1 nm, 100-day acoustic survey from Hawaii towards Mexico (RT) circa 20° N, from 15 January to 25 April, 2018. The 2,272 hours of recordings led to over 4000 cetacean detections, including unexpected numbers of minke whales, humpback whales and unidentified odontocetes. Humpback whale calls were recorded from Hawaii to 2,184 km (1,179.3 nm) to the east, or approximately midway to Mexico. Explanations for humpback whale presence in the tropical ocean basin between Mexico and Hawaii include an undocumented migration route, an offshore assembly, or mid-season travel between assemblies.

Passive acoustic monitoring of individual movements in a bottlenose dolphin population.

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Identifying individuals in a population can be crucial in conservation management strategies. Signature whistles produced by bottlenose dolphins (*Tursiops truncatus*) are an individually distinctive, dominant and stable vocal signal within their repertoire, thus providing the possibility for passive acoustic monitoring of individuals. This study focused on the population inhabiting the East Coast of Scotland. SM2M acoustic recorders were deployed in 10 different locations over the summer months of 2013, 2014 and 2015. Audio files totaling 264 hours were aurally and visually inspected. Whistle contours were given a quality index (QI) based on their visibility and signal-to-noise ratio. Whistle contours with a high QI were categorized and signature whistle types (SWTs) were determined from these categories using the SIGID bout criterion, a classification method based on the pattern of temporal production. Whistles meeting this criterion were used as templates in order to match the remaining whistles. Categories were supported during two separate visual classification tasks using 5 blind judges who were asked to match printed exemplar whistles to a subset of signature whistle templates (Fleiss Kappa statistics of $k>0.8$ and $k>0.9$). 53 unique SWTs, about one third of the estimated population size, were identified during the three-year period. The quantity and diversity of unique SWTs varied between years and among locations. Encounters were concentrated in 4 locations in all years. Preliminary mark-recapture analysis revealed individual movements both within and outside the Moray Firth SAC, and patterns of detection varied between years. One location, Stonehaven, that accounted for the majority of signature whistles in

2013 and 2015, was highlighted as being a potentially important habitat. Individual-based acoustic monitoring, using signature whistles, is a promising avenue for obtaining data complementary to visual surveys, but much work still needs to be done on whistle production and linking signatures to individuals.

Return on investment – does the inclusion of short term marks in mark-recapture studies improve abundance estimates?

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Photographic mark-recapture (MR) analysis traditionally provides abundance estimates only for those individuals identifiable from long-term marks (LTM), such as nicks and notches on dorsal fins. The number of unmarked individuals is accounted for separately using two primary methods. Most commonly, the estimates are adjusted by the proportion of images with unmarked fins, which may include repeated sampling of individuals in groups to estimate the proportion of identifiable individuals. Another option, particularly for projects of short duration and smaller populations, is to identify all individuals by also including individuals with short-term marks (STM), such as tooth rakes, scars, color variation on dorsal fin or body, and associations (e.g., mom/calf pairs). We compared abundance estimates from a sample where all individuals were identifiable using LTM and STM. During 8–26 January 2018, we conducted an MR study of estuarine-resident common bottlenose dolphins (*Tursiops truncatus*) in North Carolina, USA. All photographed dolphins were individually identified (n=476), 31% (n=146) of which were identified from STM. Using only LTM dolphins with the proportional adjustment, the abundance estimate was 806 (CI=683–972, CV=0.09). Using all identified individuals (LTM and STM), meaning that no proportional adjustment was needed, the abundance estimate was higher (941, CI=828–1090, CV=0.07). In this example, the method using the proportional adjustment may underestimate abundance. Identifying all (or most) individuals, including those with STM, is more time intensive, may have false positives/negatives, and be limited in use outside of the timeframe of a study. These issues can be offset with computer-assisted matching (e.g., FinFindR) and experienced photo-identification researchers. In addition to improving estimates of population size, the ability to identify as many individuals as possible has other benefits, such as elucidating distribution and movements as determined through photo-identification.

Changes in gillnets fishery in Polish Baltic waters in the last decade in the contex of the conservation of critically endangered population of harbor porpoises Phocoena phocoena

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Harbour porpoise (*Phocoena phocoena* L.,1758) is the only species of cetacean enhabiting the Baltic Sea. Due to low abundance of the Baltic population of harbor porpoises resulting from excessive bycatch among other threats, it was recognized by International Union for the Conservation of Nature (IUCN) as critically endangered in 2008. The major threat for this species in Polish Baltic waters is bycatch in gillnets which are the most popular gears used by fishery fleet below 12 meters operating in coastal zone, what is not beneficial to protecting the species. The area in Polish Baltic waters, where over 40% of total reported bycatch of harbour porpoises was reported in years 1990-1999 was the Puck Bay. For that reason the area was chosen to investigate the gillnet fishing activity posing a threat of bycatch for harbour porpoises. To precisely recognize the spatial and temporal fishing effort counting the set nets *in situ*, together with collecting the positions and types of nets were performed. Surveys were made in two periods: 2009-2010 and 2017-2018 years, what allowed to determine changes in fishing activity over the years. At the same time the data from the logbooks and monthly catch reports from fishery sector were analyzed, to identify spatial and seasonal fishing strategy in Polish Baltic waters. Research results indicated a significant reduction of number of gillnetters and the number of used gears operating both in Puck Bay and in Polish Baltic waters. The fishing data was confronted with the results of harbour porpoise bycatch and acoustic detections. The detailed knowledge of the strategy of small boat gillnet fishery which is not reflected in the state fishery statistics gives a unique opportunity to adjust the least harmful and well – targeted

measures of reducing the mortality of harbour porpoises on a local level.

Genetic variability and social structure in north-east Atlantic humpback whales (Megaptera noveangliae) off the Icelandic coast.

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The variability within the genes of a species gives important information on the population dynamics, which can be useful for conservation and sustainable management of endangered populations. Although north-east Atlantic humpback whales (*Megaptera noveangliae*) are not considered endangered by the IUCN, these highly mobile and long living cetaceans face multiple challenges like climate change and pollution through waste and noise. Species with high genetic variability are considered to be less susceptible to these changes and have a higher chance of evolving adaptions. In this study 110 biopsy samples of north-east Atlantic humpback whales have been collected throughout the last two decades (98 from the south-west coast and 12 from the north-east coast). DNA was extracted from these samples and the individuals have been sexed molecularly. The mitochondrial control region will be sequenced to provide insight in haplotype variability. Furthermore, 20 microsatellite loci are going to be analysed to investigate population structure as well as relatedness between individuals to test if kin selection might be a possible trait that evolved in humpback whales that feed on the Icelandic coast. These data will give an insight about the overall genetic variability in the Icelandic humpback whale population, which is in important information regarding rapid changing environments due to climate change and other human-induced stressors.

Scaling of swimming performance in the largest animals

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The scale-dependence of locomotor performance has long been studied in comparative biomechanics, but how animals move in their natural environment remains poorly understood. At the upper extreme of body mass, baleen whales are among the most efficient swimmers in terms of cost of transport through a combination of low mass-specific metabolic rate and high hydrodynamic efficiency. Such high efficiency enables these ocean giants to migrate thousands of kilometers over broad geographic ranges and underlies a major component of their life history and functional ecology. However, we lack basic kinematic data for most baleen whale species. Here we combined morphometrics from aerial drone photogrammetry, whale-borne inertial sensing tag data, and hydrodynamic modeling to study the locomotion of five rorqual species (Antarctic minke, humpback, Bryde's, fin, and blue). Using fundamental kinematic parameters of oscillatory frequency and cruising speed, we quantified spatial and temporal changes in swimming performance for individual whales and compared these metrics across a wide body size range. We also directly measured the tailbeat amplitude from tag data for one humpback whale and used that measurement to estimate the hydrodynamic efficiency. Our results showed that oscillatory frequency decreases with body size ($\sim length^{-0.53}$) while cruising speed remains roughly invariant ($\sim length^{0.08}$) at 2 m s^{-1}. We also found a trend of increased tailbeat frequencies at higher

cruising speeds. Finally, we calculated a high hydrodynamic efficiency for the single humpback whale. Our results corroborate kinematic trends shown in laboratory experiments on smaller cetaceans that found decreases in the repetitive frequency of tail movements with increasing body size. Functionally, a decrease in oscillatory frequency should lead to energetic cost-savings and an enhanced ability to transit between prey patches or migrate across ocean basins. These energetic savings help explain why rorquals have evolved to occupy such an extreme body size niche.

Presence of marine debris in the stomach contents of the marine mammals stranded in the Santos Basin, southwest Brazil.

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Marine debris, mainly plastic, are important threat to different habitats and marine biodiversity. Fauna can be heavily impacted thought the ingestion of residues and also by the entanglement and potential injuries, compromising their lives. In this context, the present study aims to investigate the presence of anthropogenic residues in the stomach contents of marine mammals along the coast of south and southeast of Brazil, from 2015 to 2019. The samples were collected through the records generated from the Santos Basin Beach Monitoring Project (PMP-BS), one of the monitoring programs required by Brazil's federal environmental agency, IBAMA, for the environmental licensing process of the oil production and transport by Petrobras at the Santos Basin pre-salt province. The carcasses that had been found were sent to necropsy and analysis of stomach contents, a total of 2476 stomachs were evaluated and waste was present in 91 individuals. Plastic fragments such as nylon, plastic seal, microplastics, straws and disposable cups were the recorded items in cetacean and pinniped stomachs. *Pontoporia blainvillei* was the species that had greatest interaction with marine debris, plastic was present in 63 animals showing large scale impact in this endangered species. The Franciscana Dolphin inhabits coastal zones and also interacts strongly with other anthropic activities such as fishing. Other species with a substantial number of individuals affected by plastic were *Arctocephalus australis* and *Sotalia guianensis* and a total of ten species of marine mammals showed interactions with marine debris. Therefore, it is important to investigate the occurrence of anthropogenic residues in the stomach contents of marine mammals in order to demonstrate the extent of their damage and to suggest mitigating measures supporting conservation action of marine life and tier habitat.

The quick and the dead: Novel sonar tags reveal predator-prey interactions in southern elephant seals.

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Despite advances in biologging technology, obtaining in-situ observations of predator-prey interactions to assess foraging effort and success remains challenging especially for deep-diving marine predators such as the southern elephant seal (SES). Here we use a new sonar and movement tag (DTAG-4) on SES to study fine-scale interactions during individual capture attempts. The tag contains accelerometer, magnetometer and depth sensor (sampled at 200, 50, 50Hz), together with a snapshot GPS and a 1.5MHz single beam sonar

with a 6m detection range (<8mm resolution) and a 25Hz ping rate. Five tags were deployed in 2018 on post-breeding female SES (Kerguelen Islands and Peninsula Valdes) yielding 4800hrs of continuous movement recordings (12,500 dives >200m). The sonar was operated at 50% duty cycle to facilitate detection of low frequency emissions resulting from the short sonar pulses. No behavioural reactions to the onset of sonar were detected in the accelerometer or depth recordings, suggesting that such low frequency emissions are effectively inaudible. Using high-level jerk transients to detect potential prey capture attempts (PCAs), we examined sonar returns in a subset of PCAs to assess predator and prey tactics. Despite the narrow sonar beam (3.4°), clear echoes consistent with targeted prey were obtained for most PCAs. About 70% of prey were elusive with escape attempts identifiable in the sonar data as sudden changes in closing speed. Prey reacted to SES at a median distance of 0.50m (IQR 0.40-0.70m) provoking pursuits within which the SES made multiple strikes, as evidenced by continued jerk transients, to capture prey. Consequently, interactions with elusive prey were significantly longer than for unresponsive prey (PCA duration: 26.5s versus 12.4s, p-value <0.001) indicating a likely trade-off between prey nutritional value and ease of capture. These high-resolution sonar data suggest that fast reactions during hunting are critical for SES to access energetic mesopelagic organisms.

Microplastics in the digestive tracts of manatees in Tampa Bay Florida

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Microplastics are of increasing concern in marine ecosystems, with potential effects on organisms including chemical leaching and physiological changes. Microplastic ingestion has been examined in carnivorous fish, marine mammals, seabirds, and plankton, little is known about effects on herbivores including West Indian Manatees (*Trichichus manatus*). As manatees graze in seagrass beds, where microplastics may accumulate, manatees may play an important role in trophic transfer of microplastics. This is the first study to examine microplastic ingestion by manatees. We selected manatee carcasses from Tampa Bay with intact digestive tracts. All manatees were necropsied using standard protocols by the Marine Mammal Pathobiology Lab which includes visual examination and manual palpation of the entire digestive tract for large plastic items. Digestive tracts were sub-sampled for smaller plastic particles by collecting 250-500 gm of material from five digestive tract segments (stomach, duodenum, cecum, distal and proximal colon). Subsamples were concentrated on 200 µm sieves and visually inspected for microplastics. Due to the high cellulose diet of manatees, it was not feasible to fully digest the gut contents. Nile Red staining along with a hot needle test and a visual examination under a compound scope was used to confirm if particles were plastic. Preliminary analysis of 10 carcasses indicated high-levels of microplastic contamination, present in all sections of the digestive tract. 80% of the manatees contained microplastics which were missed during the routine necropsies. Macroplastics were detected in 10% of the carcasses (one individual) during routine necropsy; however, we did not detect microplastics in this individual. Therefore 90% of the manatees examined contained plastics in the digestive tract. As we sub-sampled the digestive tract, it is possible this is an underestimate of plastic load in manatees. This work confirms that manatees are routinely consuming microplastics, and herbivory is an additional route for microplastic trophic transfer.

Visual cortices of cetaceans: Evidence of reduced specialization and laminar organization.

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The absence of the sense of smell in toothed cetaceans, or its extreme reduction in whalebone whales, have been described in several articles. On the contrary, the development of their visual system is seldom accounted for. In fact, the value of visual acuity is debatable considering that light diminishes considerably with depth, and that most of the light spectrum is absorbed in shallow waters. We sampled and investigated the structure and cytoarchitecture of the visual cortices of several cetacean species (*Tursiops truncatus*, *Ziphius cavirostris*, *Grampus griseus*, *Globicephala melas*, *Physeter macrocephalu*s and *Balaenoptera physalus)* to evaluate their level of complexity and compare them with the sheep (*Ovis aries*), a closer terrestrial relative, and with the macaque (*Macaca nemestrina*). Our method considered the shape and size of somata in the visual cortex and allowed us

to compare layers and their variation among individuals. Our results confirmed previous reports in the literature that indicate relatively reduced thickness and overall complexity of the cetacean cortex compared to terrestrial mammals. However, we also noted subtle differences among cetacean species that could be due to factors including *i*) diving depth and habitat; *ii*) prey type; or *iii*) degree of lateralization of the eyes. The implications could be that the visual system of highly specialized mammals such as cetaceans has little left in common with what we understand of it in terrestrial mammals and shows evolutionary divergence.

Predicting and mitigating the impacts of windfarm construction on harbour porpoises

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Predicting and mitigating impacts of offshore windfarm construction on marine mammals requires data on responses to different noise levels and sources from all construction activities. Policy and management to minimise these impacts have concentrated on pile-driving noise, and have assumed that received noise levels are directly, and positively, related to hammer energies. We investigated harbour porpoise behavioural responses to different activities (acoustic deterrent device (ADD) mitigation, piling noise and vessel activity) using echolocation click detectors, and characterised noise levels using acoustic recorders during the two-year construction of a North Sea windfarm. Porpoises were considered to have exhibited a behavioural response when the proportional decrease in occurrence was greater than the 1st percentile of baseline variation. Contrary to expectations, noise levels from pile driving decreased as hammer energy increased, in relation to pile penetration depth. A 15-min experimental ADD playback resulted in a 50 % probability of response within 3.9 km in the first 12 hours, with a minimum time to the first porpoise detection following ADD playbacks of 133 minutes. Harbour porpoise responses in the 24 hours after ADD mitigation and pile-driving combined decreased as the number of foundations that had been piled increased, resulting in a 50 % probability of response within 7.4 km at the first location piled, decreasing to 1.3 km by the end of foundation installation 10 months later. Distance proved as good a predictor of responses as received noise levels, presenting a more practicable variable for environmental assessments. Critically, both ADD use and vessel activity increased porpoise response levels. Our results highlight the need to consider trade-offs between efforts to reduce far-field behavioural disturbance and near-field injury through ADD use. Additionally, the current regulation of maximum hammer energy and the use of piling soft starts to minimise impacts may need to be reconsidered.

Investigating Brucella ceti infection in cetaceans of Italy

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Brucella ceti infections have been increasingly reported in cetaceans, although a very limited characterization of Mediterranean *Brucella* spp. isolates has been hitherto reported and relatively few data exist about brucellosis among cetaceans in Italy.To address this gap, we studied 8 cases of *B.*

ceti infection in striped dolphins (*Stenella coeruleoalba*) stranded along the Italian coastline from 2012 to 2018, investigated thanks to the surveillance activity of the National Reference Centre for Diagnostic Activities on Dead Stranded Cetaceans (C.Re.Di.Ma.).We focused on these cases of stranding, occurred along the Apulia (N=6), Liguria (N=1) and Calabria (N=1) coastlines, through the analysis of gross and microscopic findings, the results of microbiological, biomolecular and serological investigations, as well as the detection of other relevant pathogens. The comparative genomic analysis used whole genome sequences of *B. ceti* from Italy paired with the public available complete genomes.Pathological changes consistent with *B. ceti* infection were detected in the central nervous system of 7 animals, showing non-suppurative meningoencephalitis. In 4 cases severe coinfections were detected, mostly involving *Dolphin Morbillivirus*.*B. ceti*-associated lesions' severity supports the role of this microbial agent as a primary neurotropic pathogen for striped dolphins.We classified the 8 isolates into the common sequence type 26 (ST 26). Whole genome SNP analysis showed that the strains from Italy clustered into two genetically distinct clades. The first clade comprised exclusively all the isolates from Ionian and Adriatic Seas, while the second one included the strain from the Ligurian Sea and those from the Catalonian coast. Plotting these clades onto the geographic map suggests a link between their phylogeny and topographical distribution.These results represent the first extensive characterization of *B. ceti* isolated from Italian waters reported to date and show the usefulness of WGS for the understating of the evolution of this emerging pathogen.

The response of harp seals to long-term changes in Arctic sea-ice cover

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The Arctic is undergoing rapid environmental change; it is warming at twice the global average and could be ice-free as early as 2050. While these perturbations will likely result in widespread impacts, the consequences of reductions in ice cover on ecosystem function remain poorly understood. As the most abundant pinniped in the North Atlantic and a seasonal migrant between subarctic and Arctic waters, harp seals (*Pagophilus groenlandicus*) provide an excellent indicator for climate change impacts. Harp seals rely on sea-ice for breeding, and spend much of the year in association with the ice margin. In this study, we track the migration of harp seals from three breeding populations across the North Atlantic using satellite relay data loggers deployed over the last three decades. We estimate individual migration paths from satellite locations using a continuous-time state-space model, and investigate the link between harp seal migratory behaviour and summer sea-ice retreat using a space-time log-Gaussian Cox process model. We use these methods to quantify the influence of sea-ice on harp seal migratory behaviour, and then estimate the impact of changes in sea-ice under a range of future emission scenarios based on outputs from the Intergovernmental Panel on Climate Change Coupled Model Intercomparison Project. Our findings provide crucial insight into the impact of climate-change driven reductions in sea-ice cover on a key Arctic marine mammal.

Using carbon and nitrogen stable isotope signatures in vibrissae to search for clues for the cause of a California sea lion (Zalophus californianus) unusual mortality event.

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From 2013-2016, an unusual mortality event (UME) was declared by National Marine Fisheries Service because increased numbers of young (6-24 month old) California sea lions (*Zalophus californianus*) stranded along the coast of California, USA. The primary factor was malnutrition; and no significant infectious disease was detected. Environmental conditions affecting prey were identified as the preliminary cause of the UME. We submitted vibrissae segments to the UC Davis Stable Isotope Facility for carbon ($\delta^{13}C$; foraging location) and nitrogen ($\delta^{15}N$; trophic level) stable isotope analysis from dead sea lions that stranded from 2008 to 2015 (before and during the UME; n=36) as well as from live sea lions sampled during health assessments (2013 to 2015; n=15). Sea lion ages ranged from 8 to 21 months (median=15 months). We hypothesized that segments of vibrissae from stranded sea lions representing pre- and post-weaning periods would have differences in $\delta^{13}C$ and $\delta^{15}N$ during anomalous years (2009, 2013, 2014, 2015) verus normal years (2008, 2011, 2012); and that there would be differences in $\delta^{13}C$ and $\delta^{15}N$ between dead-stranded and live-sampled individuals (i.e. survivors). Using generalized linear models, we detected differences in $\delta^{13}C$ and $\delta^{15}N$ values by year; however, differences were not observed during all anomalous years. Sample year was a significant predictor of $\delta^{13}C$ values in segments from pre- and post-weaning periods, and birth year was a significant predictor of $\delta^{15}N$ in segments from pre-weaning periods. There were no differences between live-sampled and dead-stranded sea lions in vibrissae segments from pre- or post-weaning periods ($p > 0.05$; Student's t-tests). Our findings suggest that young, newly independent sea lions and nursing females are capable of altering their foraging behavior. We recommend the collection of vibrissae from dead stranded otariids because they are easy to collect and store, resistant to degradation, and contain a time series of information.

Research and protected areas, the key to conservation and to raising interest in sea mammals in the local community.

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In 1986, the Museo Educativo Patagonico (Atlantic Patagonia) formulated the objective of surveying areas of importance to the conservation of sea mammals, creating protected natural areas, managing them, encouraging future research and sharing findings with nearby communities in order to spark interest in the local population.

This is how the first survey came to be, counting 1198 specimens with 125 infants of Otaria flavescens in a reduced area. Nowadays, those numbers have increased to more than 18000 adults and 4600 offspring.

As a result of that research, 10 more protected areas were created, whose main aim is the conservation, research and diffusion of data on cetacean diversity and behavior.

Until 1934, registers show the presence of hundreds of whales in the Saint George Gulf. After a decade of commercial hunting, they disappeared for 70 years. In 1998, 7 individuals, were registered, and in subsequent years, whales were observed regularly. With the objective of setting the foundation for long term research (genetics, migration, identification of individuals, behavior), the museum began to register the sightings of species spotted along the coasts of Caleta Olivia. Individuals and groups of the following species were observed: Megaptera novaeangliae, Eubalaena australis, Balaenoptera musculus, Balaenoptera physalus, Balaenoptera borealis, Balaenoptera acutorostrata, Balaenoptera bonaerensis and Balaenoptera edeni.

In the past 3 years, more than 3000 specimens were descried each season, with permanent presence of whales. Not only the specimens' journey was registered, but also their feeding habits, copulation, socialization patterns, etc.

The increase in sightings of Mysticetos in the area suggests that a recolonization of areas historically inhabited by the species will take place in the future as the number of individuals gradually grows. Today the conservation area is offers the largest diversity in whales, and it houses the biggest population of Otaria flavescens in the world.

Understanding the role of acoustic cues in the formation and cohesion of super-groups of humpback whales (Megaptera novaeangliae)

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Humpback whales are famous for the culturally transmitted, complex song produced by males. However, both sexes produce a repertoire of social and feeding associated calls. Humpback whales off western South Africa predictably form large 'super-groups' (>20 animals) close to shore, offering the opportunity to study feeding behaviour normally limited to the Southern Ocean. Behavioural research began in 2015 using focal group follows (2015-18), static acoustic monitoring (SAM, 2017-18) and later (2018) accelerometer tags (CATS tags) in conjunction with underwater video, to investigate vocal repertoires, production rates and possible call function at the group and individual level. Research was conducted close to Cape Town (33˚54'S, 18˚25'E), within 20 km distance from shore in < 200m water depth. We identified and visually classified >7000 calls from 20 focal follows (12 recording hrs) with humpback whales. Visual classification of the 11 most common sounds types (n = 378 sounds) was supported by Classification and Regression Trees (CART) generated from call parameters, with a test accuracy of 42%. Stereotyped calls such as the 'whup' and 'grumble' made up > 30% of the repertoire of feeding whales. Combination calls and sequences were also identified, the most clear, termed the 'ABC' combination call, was found across encounters and recordings in 2015 and 16. Production rates peaked at 44 sounds per min, with rates per individual twice as high in feeding compared to non-feeding groups. Static acoustic monitoring at three coastal locations (~ 40 m depth) detected calls in October-November across years, however detection was affected by concurrent humpback whale song. The combined acoustic data indicate structural similarity in call types and combinations over time, suggesting a functional role in feeding or group co-ordination. By monitoring the occurrence of stable calls, the presence of feeding whales can be detected using long term static acoustic monitoring.

The CALVIN Project: Middle school students embedded in ongoing research; The ultimate STEM program producing (Marine Mammal) scientists in partnership with the North Atlantic right whale recovery program.

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The fifteen-year-old CALVIN Project embeds middle school students in ongoing, authentic science activities. The students call themselves the Calvineers. A high percentage of Calvineer graduates have careers in STEM fields and four are currently working in marine science fields while a number are majoring in marine science in college. The students meet once a week after school to do their own research. Students from Adams School in Castine, Maine attend three unique experiences each year where they interact with scientists from the Right Whale Consortium and the New England Aquarium who are carrying on research toward the recovery of the endangered North Atlantic right whale. Students listen to talks at conferences, talk to scientists about histories, mortalities, mitigation and research work being done. These scientists include Amy Knowlton, Scott Kraus, Stormy Mayo, Moe Brown, Michael Moore, Bill McLellen, Dan Pendleton and others from the right whale world. The Calvineers experience two whale watches guided by right whale scientists. They produce their own presentations about the endangered whales that they give to schools and organizations and have posted six award winning podcasts about current research. The Calvineers have also attended and presented at three SMM Biennial Conferences in Quebec, Tampa and Halifax. These experiences give the Calvineers a unique look into the world of science. They see that science is a complex, messy business that can be as frustrating as it is rewarding. Three Calvineers are doing research about white belly heredity, ocean acidification and plastic rope respectively. They have taken up the cause and advocate for implementation of rules reducing entanglements as well as writing Congress encouraging them to pass a bill allocating much needed funds to help save the North Atlantic right whale from extinction. The CALVIN Project is a model for successful STEM education programs at all levels.

Right whales in southern Brazil: Occurrence and photo identification in a wintering area.

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The main wintering area of the southern right whale in Brazil is located in the south-central region of Santa Catarina State, along 130km of coast protected since the year 2000 by the Right Whale Environmental Protection Area (RWEPA). In this area, the Right Whale Project / Instituto Australis have been conducted aerial surveys for photoidentification and monitoring of the species. From 2001 to 2018 (except 2014), aerial surveys parallel to the coast were carried out annually in September covering the entire RWEPA. A total of 1338 whales (including 562 calves) were recorded with an annual average of 78.70 whales. The year that resulted in the lowest number of whales was 2017, with 28 whales (including 14 calves). In the year 2018, the largest number of whales were recorded, with 259 individuals (including 119 calves). There is a trend in increasing whale numbers over the years. Since the species has a tri-annual reproductive cycle, a three-year analysis of variance was performed that did not indicate a significant difference between them (Kruskall Wallis p=0,245). From the analysis of the individual photographs, a total of 838 whale were catalogued, including 174 calves. The photoidentified individuals were included in the Brazilian Right Whale Photoidentification Catalogue which contains whales photoidentified since 1987.

Inter-annual variability in the lipid and fatty acid profiles of east Australian humpback whales (Megaptera novaeangliae) in a changing Antarctic ecosystem.

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Southern hemisphere (SH) humpback whales are classified as high-fidelity Antarctic krill consumers and as such are vulnerable to variations and long-term changes in krill biomass. A decline in Antarctic krill biomass, in years following low sea ice extent, has been observed and is hypothesized to have cascading effects on the feeding ecology of SH humpback whales in a changing Antarctic climate. Evidence of heterogeneous feeding patterns of Australian east coast migrating humpback whales has been observed, warranting a more comprehensive assessment of inter-annual variability in their diet. Here, we examined the lipid and fatty acid profiles of humpback whales sampled between 2008 and 2018 on the Australian east coast. The use of live-sampled blubber biopsies showed strong evidence of inter-annual variation in total lipid content, with differences of 21% among years. Fatty acid (FA) profiles varied among years, with 2017 being noticeably different from all other years. The two long chain omega-3, trophic indicator FAs for Antarctic krill, 20:5ω3 and 22:6ω3, were present in lower proportions than in other Antarctic krill consumers, and a decline in the proportion of 20:5ω3 was observed from 2008 to 2018. A distance-based linear model showed that 23.16% of the total variation in the FA profiles was explained by Southern Ocean environmental variables and climate indices, with most of the variation being explained by the Southern Oscillation Index (SOI; 9.73%). These results signify that higher trophic level- or extra-Antarctic feeding may play a more important role in the energy budget of SH humpback whales than previously expected or, alternatively, it may point to present-day changes in foraging patterns of an expanding population in a changing Antarctic sea ice ecosystem.

Occurrence of antimicrobial resistant Escherichia coli in marine animals in the North and Baltic Sea: Preliminary results.

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Antimicrobial resistant bacteria are a global health threat in human and veterinary medicine, with a rapid emergence and expansion worldwide. Wildlife species can play an important role as reservoirs for these organisms. Information regarding prevalence and transmission pathways is especially lacking for marine species, which are highly vulnerable to the introduction of treated sewage in natural waters and to the enhanced horizontal transmission of resistance mechanisms naturally occurring in aquatic ecosystems. The investigation of marine and coastal animals of the North and Baltic Sea of Schleswig-Holstein, Germany and the western Baltic Sea of Denmark for antimicrobial resistant *E. coli* shall determine the current situation in these areas. Up to now, 141 rectal/cloacal and faecal swabs were collected from sea fish, coastal birds and marine mammals. The collected swabs were incubated in Mossel bouillon and the suspensions were streaked on eight different antibiotic containing MacConkey agar plates. Bacterial colonies were screened for presumptive coliform bacteria via three different selective agar plates (Gassner, MacConkey and Chromocult agar). *E. coli* species confirmation was performed by PCR assay. Confirmed isolates were tested in disk diffusion tests for their resistance against 14 antibiotics or antibiotic combinations. Resistant *E. coli* were present in 34.8 % of the samples. With 55 % positive samples, birds had the highest occurrence of resistant *E. coli*, followed by the marine mammals with 33.3 % positive samples. No *E. coli* were identified in any fish sample. The most frequent resistances detected were against streptomycin and ampicillin (all data as of April 28th 2019). The high occurrence of resistant isolates from sampled birds and marine mammals were unexpected. Further investigations will determine resistance genes and virulence factors. The obtained data might elucidate potential risk factors for the transmission of resistant bacteria or resistant determinants to livestock, companion animals and humans.

Estimating circulating concentrations of cortisol in large whales via blow sample collection with an unmanned aerial vehicle.

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Monitoring physiological stress in wild animals is crucial to assess the impact of environmental stressors on individual fitness. However, measuring physiological parameters, such as the mammalian stress-related hormone cortisol, is challenging in free-ranging cetaceans. Procedures for collecting biological samples are often expensive and intrusive, e.g. collection of exhaled breath ('blow') samples usually relies on a research vessel being in close proximity to the target animal, while extending a long pole and collection device into the blow.

With advance in technology, sample collection with unmanned aerial vehicles (UAVs) represents a potential solution, being affordable and relatively unobtrusive. We present a methodology to (accurately) measure cortisol in the blow of large whales via UAV collection.

Blow samples were collected from humpback whales (*Megaptera novaeangliae*) in northern Iceland in 2018, using a DJI Phantom 4 UAV with 100 mm Petri dishes attached as a collection device. Samples were collected up to 2.2 km from the UAV pilot. Following storage at -20°C, samples were extracted from Petri dishes with an ethanol-water (50:50) wash, followed by reconstitution in water-methanol (70:30; 100 µL).

Cortisol was detected in samples following reverse-phase liquid chromatography- mass spectrometry on a C18 column and a Sciex QTRAP 6500+. Accounting for biological sample dilution by measuring the concentration of urea and three ions (sodium, potassium, chloride) in each sample, we aim to use this method to monitor the physiological stress response of humpback and blue whales (*Balaenoptera musculus*) to whale-watching encounters in Skjálfandi Bay, Iceland. Monitoring this physiological response forms part of a larger framework, including behavioural observation and body condition measurement, to assess the impact of ecotourism on cetacean populations.

The status of mediterranean monk seal (Monachus monachus) in Çandarlı Bay from 2015 to 2018, Turkey

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This study was conducted to evaluate the current status of endangered Mediterranean monk seal (*Monachus monachus)* between 2015 and 2018 in Çandarlı Bay, Turkey. The study was performed by collecting monk seal sighting records of previous two years from local fishers in the area, and the asessment of the footage captured in the coastal caves by camera traps that were placed within the context of marine monitoring works of the STAR Refinery.

During the questionnaire surveys which conducted between 21 March 2017 and 21 August 2017, a total of 11 monk seal sightings were obtained from 58 coastal fishers in Aliağa, Yeni Foça, Yenişakran and Çandarlı. Out of 11 monk seal sightings, 7 of them obtained from Yeni Foça, 1 of them gathered in Aliağa, and 3 of them obtained from Yenişakran. Considering the demographic distribution of the observed individuals by fishers, it was reported that the percentage of the adult individuals had the highest ratio (73 %), while the younger individuals had the lowest (9 %). Out of 45,356 pictures taken at six coastal caves during in cave monitoring, no seal footage was obtained.

All in all, with very few sightings and no recordings of any monk seals from caves dictates the fact that the area is no longer used by the resident monk seals in Çandarlı Bay. However, possible visiting individuals around Yenifoça should not be overlooked in the future monitoring studies. The camera traps for the in cave use monitoring study was financed by STAR Refinery.

Seasons and submarine shakes: Dynamic habitat use by sperm whales in a highly productive, earthquake-struck canyon.

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Flexibility in habitat use by top predators is vital for meeting their high energy requirements in a patchy and changeable marine environment. The Kaikōura Canyon (New Zealand) is a highly productive deep-sea habitat, and a year-round foraging ground for sperm whales. The number of whales visiting Kaikōura during summer has declined over the last three decades, potentially driven by oceanographic and ecological changes within the whales' habitat. Furthermore, a 7.8 magnitude earthquake triggered extensive erosion in the canyon in 2016, causing large-scale removal of benthic biomass. We investigated the drivers and seasonality of the whales' foraging distribution, and whether habitat use was influenced by the earthquake. Sperm whale locations (n=486) and diving behaviour (n=325) were recorded during boat-based surveys over three pre-earthquake and one post-earthquake year. We used species-distribution models to relate whale presences and absences to habitat variables at a fine spatial scale, including seafloor topography and in-situ water-column measurements. Habitat preferences differed substantially between summer and winter, probably reflecting temporal patterns in prey availability. In winter (33% explained variance), whale presence was correlated with depths of 500-800m and areas of low sub-surface chlorophyll; in summer (28% explained variance), whales foraged more often over depths of 1000-1300m and steep slopes, in areas with strong vertical temperature gradients. Sperm whales appeared to modify their foraging patterns in response to the earthquake. A 25% increase in the duration of surface intervals for over a year may have reflected increased effort searching for prey, while a shift in spatial distribution was probably driven by reduced prey availability in the upper canyon, where erosion was most severe. Flexibility in habitat use over seasonal cycles and after natural disturbance events highlights the dynamic foraging ecology of sperm whales. This is the first study to quantify the impact of an earthquake on a cetacean population.

Validating the use of fatty acids for quantitative diet estimation in marine mammals.

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Fatty acids (FAs) have proven to be a useful qualitative tool to elucidate dietary patterns; however, its quantitative use in foraging studies has seen a slow growth compared to other biochemical methods such as stable isotopes. Here, we use the Bayesian tool, MixSIAR, to estimate diet of five species of marine and terrestrial mammals, based on FA data of consumers with known diets. Simulations based on real FA data derived from feeding studies allowed us to evaluate performance under different scenarios: using different subsets of FAs; using calibration coefficients (trophic fractionation) derived from other consumers and/or other sources; and when animals had been fed single or multiple diets; as well as when diets had

changed over time. In most cases, FAs correctly predicted diet preferences, even when the calibration coefficients used were derived from other species. The use of a subset of FAs produced more accurate results and reduced computational time. The use of calibration coefficients derived from other consumers does not seem to have a great impact on the predicted outcomes, however, if the calibration coefficient is derived from an animal eating a food source, which at the same time is one of the sources used in the model, it could lead to overestimation of that source. Given these results, we then applied this method to wild Antarctic seals, using blubber FAs and whisker stable isotopes to estimate diet. Both biotracers correctly identified the main components of the diet of each seal, but FAs provided a better taxonomic resolution, due to their greater power of distinction among prey species. This work promotes the use of FAs when feeding experiments are not feasible. We suggest that this Bayesian approach, formerly only applied to stable isotopes, has the potential to correctly estimate diets when applied to FA data.

Spatiotemporal trends and risks of per- and polyfluoroalkyl substances in Indo-Pacific humpback dolphins from the Pearl River Estuary, China.

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The Indo-Pacific humpback dolphin population (*Sousa chinensis*) from the Pearl River Estuary (PRE) have suffered catastrophic declines in recent decades, primarily due to degradation of habitat quantity and quality. High levels of environmental pollutants found in the PRE humpback dolphins could potentially disrupt immune and reproduction system, making them vulnerable to disease and leading to dwindling birth rates in exposed populations. However, baseline knowledge of PFAS levels and trends in humpback dolphins from the western PRE is still lacking. Per- and polyfluoroalkyl substances (PFASs) are a group of highly persistent chemicals that have different bioaccumulation behavior in relation to lipophilic POPs. Sixteen PFAS compounds were measured in liver and kidney tissues of the PRE dolphins between 2004 and 2016. The average concentrations of PFOS, PFOA and most of the other PFASs in liver samples were respectively greater than any records previously reported in cetaceans globally. For the first time, we found a U-shaped trend for the distribution pattern of PFCAs between liver and kidney with increasing carbon chain lengths, whereas a descending trend was found for PFSAs, which may be explained by binding efficiencies of PFAS analogues to proteins. The fine-scale spatiotemporal distribution pattern of PFASs in dolphins from the estuarine region indicated that stranding location and time might be important predictors in the contaminant load in these animals. Risk assessment results showed that 46% of PFOS concentrations exceeded the Tentative critical concentration for PFOS than 35% of those in Hong Kong dolphins were above this value. Therefore, we suggested that PFOS exposure is an important understudied concern for the PRE dolphins, especially for females. Our findings contribute to the knowledge of tissue distribution and spatiotemporal trends of PFASs in the PRE dolphins, which are valuable for us to understand the PFASs exposure risk and their industrial emission in Southern China.

A critical analysis of the French marine mammal monitoring programme for MSFD first cycle, and perspectives for second cycle 2020-2026.

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The Marine Strategy Framework Directive (MSFD, 2008/56/EC) aims to restore the Good Ecological Status (GES) of European marine waters through six-year action cycles. The first cycle started in 2012 with an initial evaluation of the GES and the definition of environmental targets, followed by the adoption of monitoring programmes in 2014 and of programmes of measures in 2016.

13 thematic monitoring programmes were worked out in France, among which one is dedicated to marine mammals and marine turtles, with 5 sub-programmes:

- SP1: Coastal populations of cetaceans
- SP2: Seal populations
- SP3: Marine mammals and marine turtles at sea
- SP4: Stranding of marine mammals and marine turtles
- SP5: Interactions with human activities

Each sub-programme includes different monitoring systems that gather data in order to inform GES criteria, but also to evaluate the achievement of environmental targets and the efficacy of measures.

This first monitoring programme will end in 2020 and discussions have started to update it for next cycle 2020-2026. Recommendations were made by

the European Commission in 2017, and a critical analysis was conducted in 2019 to assess the relevance of each monitoring system with regards to the revised GES criteria of EU Decision 2017/848 and to the 2018 evaluation of marine mammal GES in France.

For the second cycle, a combination of new and upgraded monitoring systems will be implemented to fill the data gaps, notably for large species and for the Mediterranean Sea, including an acoustic monitoring of coastal (SP1) and pelagic (SP3) cetaceans, aerial counting of the main seal hauling sites (SP2), observers on ferries (SP3) or bycatch surveys (SP5). In response to European and national requirements, the use of new monitoring technologies and data from citizen science will be also tested.

Energetic consequences of human disturbances and changes in krill preyscape on blue whales foraging in the Estuary and Gulf of St. Lawrence, Canada.

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Blue whale survival and fitness is highly contingent on successful foraging and efficient food acquisition during intense feeding seasons. For marine air-breathing mammal, efficient foraging is constrained by oxygen acquisition at the surface and krill patches density and availability at depth. Thus factors that affect either of these components are likely to alter foraging effort and overall foraging efficiency. Here we examined the energetic consequences of a demonstrated reduction in blue whale dive and breathing times caused by vessel proximity, and of potential variations in krill preyscape as a result of selective fishery or global warming on foraging effort and energy storage capacity. Blue whale net energy gains and foraging efficiency were estimated through model simulations for different scenarios of krill density, vertical distribution, and krill species dominance ratio (2 different species), and for different degree of perturbation in foraging time and breathing time. Vessel proximity within 400 m of foraging blue whales reduced net energy gain by 15% when continuously present over a 3h period, and by more than 50% for a simulated continuous presence over a 12 hr daylight foraging period. While variations in krill species composition, density or vertical distribution, had more moderate effects on blue whale net energy gain over the range of scenarios tested in this study, they were still notable in some cases, particularly in the event of a decrease in krill density. For a species like the blue whale, which relies on a short feeding season and almost exclusively on krill for building energy reserves, changes in energy gain through altered krill preyscape or repeated human disturbances might be of special concern for the conservation and management of this endangered population.

The use of novel bio-logging technologies to investigate high mortality rates in juvenile southern elephant seals and links to dive and forage ability

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High juvenile mortality rates are typical of many long-lived marine vertebrate predators. Insufficient dive and foraging ability are considered key drivers of this, which for many species need to develop rapidly as individuals quickly transition from full parental care and provisioning to complete independence. However, direct links sparse, predominantly due to the difficulties of remotely observing free-ranging marine animals that may not return to land.

In this study, we present a new method for the remote abstraction and transmission of accelerometer data collected via bio-logging technologies. Using this technique, we tracked the fine-scale behaviours and movements of 20 juvenile southern elephant seals *Mirounga leonina* during their first months at sea following weaning. Retrieved archival data from 9 individuals was used for validation. Links between survival outcome (determined via double tagging) and dive and forage ability were then investigated using a combination of Cox's proportional hazard regression and penalised shrinkage.

Abstracted transmissions included estimates of time spent in prey catch attempt behaviours and swimming effort, and reflected those from standardised processing of retrieved archives. Of the 20 individuals tracked, nine died and 11 survived. Common causes of death included increased horizontal travel speeds, decreased development in dive and forage ability, and habitat type visited.

The methods presented in this study can be used to provide novel insight toward the behaviours and movements of free-ranging marine predators from whom logger retrieval is challenging. Moreover, the factors driving early mortality can also be elucidated. For southern elephant seals, the first few months of life following independence represent a critical period for survival, when small deviations in behaviour from the norm appear sufficient to increase mortality risk. As such, this species may be particularly vulnerable to changes in climate and environment, which will have concomitant consequences on the demography and dynamics of populations.

Analysis of scars on dorsal fins caused by conspecifics indicate sex-specific differences in the behavioral patterns of lahille´s bottlenose dolphin (tursiops truncatus gephyreus)

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Due to its strictly aquatic habit, free-living cetacean behaviour observation is very limited, especially in turbid waters. However, inferences about behavioral patterns of some highly social species can be made by analyzing scars on their bodies caused by conspecifics. The current work evaluated the potential sex-specific differences in aggression of bottlenose dolphin throughout the analysis of temporary and permanent marks on dorsal fin of 20 adult individuals of know sex (10 males and 10 females). We selected high-quality dorsal fin photographs obtained during photo-identification surveys of bottlenose dolphins in Patos Lagoon Estuary, southern Brazil. Temporary marks were evaluated for intensity and proportion of dorsal fin coverage, plotting the entire fin surface and calculating the scars percentage relative to the total dorsal fin area in pixels using Photoshop software. For this analysis, only photos of the left side of the dorsal fin of each individual taken during the cold season (May to October) were used. Changes in permanent marks pattern were monitored over an 8yr period according to the number of marks and tissue loss intensity (smooth, moderate or significant). A higher intensity and coverage of temporary marks on the male's dorsal fin were observed (mean=32%; DP=6%) comparing to the females (mean=16%; DP=3%) ($t=7.6393$; $p<0.001$). Overall, females presented few and smoothed to moderated permanent marks in their dorsal fins that remained constant throughout the years, while males presented much higher number of permanent marks and significant tissue loss, which amplified in length and depth over the years. The results indicate a more aggressive behavior among males, probably related to social battles for female access, which appear to be more tolerant in their social life. Our results indicate that data from natural dorsal fin marks can be used as an additional feature for sex recognition of individuals in this population using photo-identification.

Regional and seasonal distribution of stranded cetaceans in Jeju Island, Republic of Korea, from 2014 to 2018

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Cetacean stranding gives us valuable information on marine mammal diversity and their ecology. However, no long-term survey of stranded cetaceans has been conducted in Jeju Island, Republic of Korea. Reports of stranded cetaceans in Jeju Island have been recorded through maritime police network. Among the collected data, the following credible information are used to investigate regional and seasonal stranding distribution: date, location, and species. From March 2014 to November 2018, 125 finless porpoises (*Neophocaena phocaenoides*) (76.2%), 28 Indo-pacific bottlenose dolphins (*Tursiops aduncus*) (17%), and 11 other cetaceans (6.7%) were stranded. Finless porpoises were mostly stranded between November and April, and they

were regionally distributed on the Northern coast of the island. On the other hand, Indo-pacific bottlenose dolphins showed seasonal variation but no significant patterns in regional distribution. Among other cetacean species, two were unidentified, and no regularity was found in both region and season. According to previous researches, finless porpoise lives in inshore of the South and Yellow Sea of Korea. There is a high probability that finless porpoises were caught by bycatch during winter fishery activities in their habitat area and drifted to the northern coast of Jeju Island. Additional research of habitat, distribution and population size is necessary to further understand this result and the ecology of the species. As a residential population, Indo-pacific bottlenose dolphin lives all around the inshore of Jeju Island, therefore, non-significant differences in regional distribution of stranding were noted. The seasonality of the standing may be explained by the higher number of visitors to the inshore area during summer to witness and report the stranding to the authority. The life history of Indo-Pacific bottlenose dolphins has not been fully explored in this study area. More detailed and extensive research of stranded Indo-pacific bottlenose dolphin can increase our understanding of the species' ecology.

Assessing the performance of open source, semi-automated pattern recognition software for harbour seal (Phoca vitulina) photo-identification data

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Photo-identification (photo-ID) is a well-established, non-invasive, and cost-effective technique to collect longitudinal data of species that can be individually recognized based on natural markings. This field has been revolutionised by computer-aided software for pattern recognition, speeding up the processing of large numbers of images. Freely available algorithms exist for a wide range of species, but the choice of algorithm can have significant effects on the accuracy of the individual histories and, consequently, on derived demographic parameter estimates. We tested the performance of three open source, semi-automated pattern recognition algorithms on harbour seal photo-ID data: Wild-ID, I^3S Pattern and ExtractCompare. We also tested for the effects of database size and of data collection method (camera-lens versus camera-scope) to inform future fieldwork protocols. All algorithms generate similarity scores between pairs of images and the top 20 potential matches were inspected. The false rejection rate (FRR) of each software and the cumulative density function (CDF) for the ranks of true matches were calculated. Wild-ID had the lowest FRR (0) and ranked true matches highest (70% at rank 1). I^3S Pattern had a higher FRR (0.1) than Wild-ID and ranked true matches lower than both Wild-ID and ExtractCompare (50% at rank 1). ExtractCompare had the highest FRR (0.2) but ranked true matches higher than I^3S Pattern (60% at rank 1). Database size had a smaller effect on algorithm performance than expected, and the method of data collection by camera-lens outperformed camera-scope in every trial. Software algorithms have their own specific limitations, but ExtractCompare is currently the only pattern recognition software that accounts for orientation and torsion by using a 3-dimensional model. However, by selecting an area of the body where torsion is limited (i.e. the head), we are confident that Wild-ID outperforms both I^3S Pattern and ExtractCompare in harbour seal photo–ID data processing.

How social media is changing the way we learn about cetaceans in remote locations: Bringing 60o N sightings to the masses.

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Shetland has long been an important area for cetaceans and seals due to its proximity to the European continental shelf. However, the isolated and exposed position at 60° N also makes it difficult for surveying with most data collection restricted to land based surveys by citizen scientists. The last few years have seen substantial increases in sightings around Shetland. Since 1970, there have been over 4500 cetacean sightings with 1600 (36%) in the last decade. The question arises whether this is a genuine increase or a consequence of improved communication networks. Are we simply getting better at reporting their presence around our coastal waters? Here we assess the sighting trends of five regular species: harbour porpoise, Risso's dolphin, killer whale, minke whale, and humpback whale. For the larger species, there are sighting

increases that correspond with when particular social media platforms came on stream. However, for harbour porpoise there is an opposite trend with citizen scientists only reporting unusual group sizes. A comparative analysis with effort corrected density data found that these large increases were unsupported. Sightings data were also examined to better understand site fidelity and movements. Photo ID was formerly restricted to scientists but through camera improvements and the power of social media, the quality and availability of photos has improved dramatically. Increasing social media reporting (Shetland Orca Sightings Facebook 14,000 followers and the WhatsApp group 256 users) means it is now possible to track killer whale pod movements in real time, or determine whether sightings of humpback whales or Risso's dolphins, days, or even years apart, are the same individuals. These findings show that social media can play an important role in both future conservation and public awareness of cetaceans but that data collection methods need to evolve to work with these platforms.

Anthropogenic factors important for seascape genetics in the Florida manatee.

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The intersection of population genetics and landscape ecology is known as seascape genetics when assessed in marine systems. Drivers of these patterns can be difficult to determine as marine systems are diffusive and ephemeral and populations of marine organisms are often large and highly mobile. The Florida manatee presents an especially difficult case as a previous study on their population genetics revealed low levels of genetic diversity. Even so, seascape genetics has proved useful in understanding spatial distribution of genetic variation in populations with weak differentiation, low diversity, or chaotic structure. Gene movements across a seascape can be described by various distance hypotheses, including Isolation by distance, least cost path analysis and/or circuit theory (CT). The goal of the present study was to elucidate if any distance hypothesis based on abiotic (bathymetry, temperature, salinity), biotic (chlorophyll-a concentration, seagrass cover), anthropogenic (boat activity, coastal habitat disturbance), or a combination of factors could explain spatial patterns of genetic distance (GDis) in manatees. A GDis matrix was generated between all pairs of 293 individual manatees in the dataset using 20 microsatellite loci and the proportion of shared alleles (Dps). Each seascape variable was objectively parameterized using eight transformations. Mantel tests were used to select informative ecological distance hypotheses and maximum-likelihood population-effects mixed modelling (MLPE) was used to to select the model that best explained GDis based on Akaikes corrected Information Criterion (AICc). Results from the MLPE mixed modelling bootstrap (10,000 iterations) revealed that CT distance based on boat activity was selected as the top model (86.52%) followed by CT distance using coastal habitat disturbance (13.42%). The results of this study 1) add to a body of literature in seascape genetics, and 2) suggest that anthropogenic boat activity and coastal disturbance have created spatial genetic structure by disrupting gene flow.

Cetacean strandings in Iceland 1980-2018

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Since 1980, the Marine and Freshwater Research Institute (MFRI) has systematically kept records on cetacean strandings in Iceland. Such long-term stranding databases are generally regarded as an important method of collecting information on the marine environment. Information from strandings constitutes the most important source of biological/ecological data on many species of cetaceans in Icelandic and adjacent waters. Depending on circumstances (species, accessibility etc.) the MFRI and cooperating scientist have arranged for sampling and measurements of the carcasses.

Here we analyse the data on whale stranding in Iceland in the period 1980 to 2018. A total of 480 stranding events have been registered in the period consisting of 18 identified species. The total number of animals were 714 with the pilot whale accounting for the highest number of animals or 256 (including two mass strandings). The most frequent species to strand was the sperm whale (*Physeter macrocephalus*) (86 events, 98 animals) The database includes several records of two species, previously unknown for the Icelandic waters, the striped dolphin (*Stenella coeruleoalba)* and Sowerby's beaked whale (*Mesoplodon bidens*).

Both species have their main distribution south of Iceland.

The number of reported strandings has increased over time, but the reason for this is unclear and it is possible that the schematic cooperation between corresponding parts introduced in 2007 has made the reporting more efficient.

In the year 2018, 42 stranding were registered in the MFRI database, the highest number ever. The unusually high number (19) of Northern bottlenose whales (*Hyperoodon ampullatus*) and other Ziphiids (4) are noteworthy in the light of an unusually high number of strandings of these deep divers in the eastern North Atlantic that same year. The cause(s) of these events is still a matter of scientific debate and investigation.

Predicting summer fin whale distribution in the Pelagos Sanctuary to identify dynamic whale-vessel collision risk areas

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Mediterranean fin whales aggregating in the Pelagos Sanctuary in summer to feed are exposed to vessel collision risk, particularly from high-speed ferries travelling through their habitat. Understanding summer fin whale distribution is key to identifying areas with potentially high collision risk. We developed predictive models to predict summer fin whale distribution using a Generalised Additive Model (GAM) and MaxEnt, and identify high risk areas along ferry routes in the Sanctuary. Data were collected in summer 2016-2017 on board ferries crossing the central area of the Sanctuary. Environmental predictors included bathymetry and mean sea surface chlorophyll concentration (*chl*) of the annual spring bloom period. We compared the predictive ability of GAM and MaxEnt based on current scientific knowledge of fin whale distribution in the Sanctuary. Collision risk was estimated as a function of the overlap between the probability of fin whale occurrence and ferry density estimated from AIS data. A total of 81 surveys were conducted in 2016-2017, resulting in 127 fin whale sightings. GAM (deviance explained=23.9%) predictions were relatively more reliable than that of MaxEnt. MaxEnt's predictive ability was likely hampered by the inability to incorporate the temporal component of data into model construction. Despite the differences, both models highlighted two recurring high collision risk areas in the summers of 2016 and 2017: in the western offshore region and the south-east region over the Bonifacio gyre. Other areas were less predictable, with risk being more widespread in 2017. Our results showed that the spring bloom *chl* is a unique predictor allowing a yearly forecast of summer fin whale distribution and demonstrated the possibility to dynamically manage whale-vessel collisions in the Sanctuary. Overcoming the modelling limitation related to MaxEnt would present an opportunity to collate data from various sources, including opportunistic sightings, to increase sample size and improve model predictions.

Estimation of population dynamics for the Antarctic blue whale using bayesian state-space models

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The Antarctic blue whale was decreased its abundance by commercial whaling from 1920s to 1960s, and it has been listed as an endangered species in IUCN. Providing a valid estimate of the current abundance and increasing rate are crucial to see the extent of recovery of this population. However, due to a limited number of detections of this species during surveys, the precision of abundance estimates in each survey itself has large uncertainty. To overcome this difficulty, we propose the use of Bayesian state-space models to strengthen the separate estimates over space and time.

Sighting surveys for this species were conducted by several research programs such as IDCR-SOWER (1978/79-2003/04) and JARPA/JARPAII (1989/90-2008/09). In this study, we analyzed population abundance and dynamics of an area of south of 60 degrees South latitude between 70 degrees east to 170 degrees west longitude. Abundance estimate in Branch (2008) were used previous studies for IDCR-SOWER and those for JARPA/JARPAII were updated. Based on those abundance estimates, state-space surplus production models were estimated using a Bayesian method.

As results, the current depletion level of this species was still very low while the intrinsic rate of natural increase was estimated as slightly higher

than those for other baleen whales. Although this analysis has not accounted for any species interactions among whale species and environmental changes in the Antarctic Ocean and it is not easy to construct a whole ecosystem models, we will introduce results by possible extensions of our models to incorporate estimated population dynamics of other species as density-dependent factors beyond species.

Cognition in the wild: Dolphin communication during a role-specialized foraging tactic.

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A division of labor with role specialization is defined as individuals specializing in a subtask during repetitions of a group task. This behavior is ubiquitous in humans, but there are currently only three confirmed examples found among non-human mammals; lions, mice and bottlenose dolphins. The population of bottlenose dolphins (*Tursiops truncatus*) in Cedar Key, Florida, are well known for their role-specialized foraging tactic. During "driver-barrier feeding", a "driver" dolphin herds mullet (*Mugil* spps.) towards "barrier" dolphins and as the prey are trapped they leap out of the water, where the dolphins catch them in air. However, it is currently unknown how dolphins coordinate driver-barrier behavior. By recording vocalizations with a hydrophone array during a subset of more than 300 observed instances of driver-barrier feeding by 12 different driver individuals, this study is the first to investigate how bottlenose dolphins coordinate during role-specialized behavior. Results of fine-scale audio and video analysis during a subset of ~80 driving events with highest audio quality suggests that barrier animals cue on outgoing and/or reflected echolocation signals from the driver individual. Analyses of temporal patterning of whistles before and after driving events help determine if animals may use signals to influence the behavior of others to coordinate during the behavior. The results of this study inform our understanding of the role dolphin vocalizations play in group feeding.

Marine mammal "hotspots" in the Greenland and Barents Seas as revealed by satellite tracking since 2005

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Large-scale changes are currently taking place in the Arctic due to global climate change. Sea-ice declines and other environmental changes are directly impacting Arctic ecosystems and are also leading to increased levels of human activity in this region, including increases in shipping, tourism, oil and gas exploration and fishing. Identifying marine mammal "hotspots" is thus critical for safeguarding these species and their habitats. Marine mammal biotelemetry data from 528 individuals, including 12 species (20 bearded seals (*Erignathus barbatus*), 60 harbour seals (*Phoca vitulina*), 20 harp seals (*Pagophilus groenlandicus*), 20 hooded seals (*Cystophora cristata*), 73 ringed seals (*Pusa hispida*), 33 walruses (*Odobenus rosmarus*), 23 bowhead whales (*Balaena mysticetus*), 18 white whales (*Delphinapterus leucas*), 235 polar bears (*Ursus maritimus*), 10 blue whales (*Balaenoptera musculus*), six fin whales (*Balaenoptera physalus*) and 10 humpback whales (*Megaptera novaeangliae*)), tagged around Svalbard, eastern Greenland and in the Fram Strait from 2005 to 2018 were analysed to identify marine mammal hotspots and areas of high species richness in the Greenland and Barents Seas. Getis-Ord G_i* hotspots and areas of high species richness were around the Svalbard Archipelago and in the marginal ice zone of the Greenland and Barents Seas. Hotspots calculated using the number of individuals and number of locations were similar, but location-hotspots better captured foraging areas

that were used heavily by only a few individuals. Hotspots were more dynamic seasonally for species with large-scale movement patterns (e.g. harp seals, hooded seals, bowhead whales, polar bears) than for species that occupy smaller areas during their annual cycles (e.g. bearded seals, ringed seals, white whales). These analyses identify important areas for conservation and management efforts but it is important to note that conservation plans will need to be flexible due to the high intra- and inter-annual variability in the location of the marginal ice zone.

Genetic identification of North Atlantic right whale calves challenge our assumptions of growth, weaning and survival.

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North Atlantic right whales, *Eubalaena glacialis*, are one of most endangered of the large whales with a current estimate of only 411 individuals. The life history parameters of this species have been tracked by an extensive photo-identification catalog since 1980. One weakness of photo-identification is that it cannot be applied to right whale calves until they are around four to five months old: the time required for their callosity pattern, the primary identifying feature, to develop. Sixty percent of the 477 calves born between 1988 and 2017 were genetically sampled as calves and 20% of those were not photographically identified. Here we use genetics to link seven of those calves to photographed sightings when they were not with their mothers- either later in their birth year or in subsequent years. Three of these were suspected to be dead (because their mothers were always alone after leaving the calving ground), but genotyping proved them to be alive. These calves may have separated from their mothers much earlier than the standard October to December separation time. One dead whale that had been classified as a calf based on its length was identified as a yearling, indicating substantial variability in physical growth rates. In three other cases, juveniles were linked back to calves from previous years that had no photo-identification information, providing information on their age and parentage. Given the wealth of information that is lost when calves cannot be linked to their mothers, genetically sampling calves on the calving ground is critical for ongoing efforts to assess and monitor trends in this species, and to test the accuracy of assumptions based on field observations. This urgency is magnified by a recent distribution shift away from known summer habitats, resulting in gaps in the photo-identification data.

Citizen science in the marine environment: A case-study estimating common dolphin densities.

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Citizen science is increasingly popular and has the potential to collect extensive datasets at lower costs than traditional surveys. Ferries have been used to collect data on cetacean populations for decades, providing long-term time series allowing for monitoring of cetacean populations. We estimate common dolphin (*Delphinus delphis*) densities in north-east Atlantic and investigate the use of citizen science data to identify changes in marine mammal densities and areas of importance.

Data were collected by citizen scientists on ferries between April and October in 2006 - 2017. Common dolphin sightings data from the Bay of Biscay (n= 569), a short ferry route in the SW of Cornwall (n= 260), and English Channel (n= 75) were used to estimate detection probabilities with detection functions. Density Surface Models estimated density across ferry routes.

Overall detection probability was highest in the English Channel (0.384) and Bay of Biscay (0.348), and lowest in the SW of Cornwall (0.158). Common dolphins were estimated to occur in higher densities off Cornwall (0.400 per km^2) and the Bay of Biscay (0.319 per km^2), with low densities in the English Channel (0.025 per km^2). Densities off Cornwall appear relatively stable on the ferry route since 2006 with a slight decrease in 2017. Densities peaked in the Bay of Biscay in

2013 with lower numbers since. The general trend in the English Channel appears to be increasing densities of common dolphins over time since 2009.

This study highlights the effectiveness of citizen science data to investigate the distribution and density of cetaceans. The densities and temporal changes shown by this study are representative of those from wider-ranging robust estimates. We highlight the ability of citizen science to collect data over extensive periods of time which complements traditional surveys.

Multidecadal tooth growth chronologies allow insight into environmental influences of energy budgets and foraging movements of sperm whales from southern Australia.

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In a changing climate, determining the environmental influences on energy budgets (which underpin population state) is fundamental for informing how populations may fare under future conditions. We applied novel modified dendrochronology (tree-ring science) techniques to teeth collected from deceased sperm whales (*Physeter macrocephalus*) across two sites in southern Australia (sampled across four time periods; from whaling archives and mass strandings) to establish chronologies of annual tooth growth (as a proxy for energy budgets) spanning 70 years (1935 – 2004). Generalised additive models were used to investigate relationships between tooth growth chronologies and three indices of climate phenomena associated with the El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), and Southern Annular Mode (SAM). Positive phases of the ENSO and the SAM, and negative phases of the IOD positively influenced tooth growth. The relationships varied among groups of whales, indicating that environmental drivers of relevance for the region impart differing intra-specific influences on the energy budgets of sperm whales. Correlations between chronologies and spatially explicit, seasonally averaged sea surface temperature (SST) showed that cooler SSTs also positively influenced tooth growth and identified spatial differences in foraging patterns between sample groups. These findings suggest that sperm whale groups across the southern Australian region utilise distinct foraging areas and are subject to differing regional effects of climate-driven variability. This study therefore represents an important step in understanding potential areas of foraging significance for sperm whales that inhabit southern Australian waters, and a means by which we can begin to quantify the effects of ongoing climate change on populations of this species.

Grey seals in the Northwest Atlantic: Conservation success affects growth and condition.

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The Canadian component of the Northwest Atlantic grey seal population (*Halichoerus grypus*) increased from around 5000 animals in 1960 to over 400 000 animals in this decade and although the population continues to increase, the rate of increase has slowed suggesting that density-dependent factors are affecting the dynamics of this population. We examined changes in growth in body length, mass and condition of grey seals measured between 1954 and 2018. Grey seal males are significantly longer (x=218 cm) and heavier (x=218 kg) than females (x=192 cm and 163 kg, respectively). Residuals from the female standard length Von Bertalanffy growth curve decreased with year of birth, at a rate of -0.12 cm·year^{-1}. Changepoint analysis on these residuals detected a significant decline in length at age from 2001 onward. Likewise, residuals from the female body mass curve decreased by -0.27 kg·year^{-1} from 1970 to 2018. Changepoint analysis identified that body mass has been lower than expected since 2006. While changes in body length were associated with changes in abundance, changes in body condition were instead associated with changes in environmental variables such as duration of ice cover and prey abundance. Age specific reproductive rates of females aged 5 and 6 years old have decreased significantly, while reproductive rates for females aged 7 years and older have shown no change. Our results show that density dependent factors are beginning to affect the dynamics of this population.

Decadal-scale changes in cetacean species-habitat relationships and distribution in summer in European Atlantic waters

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In recent decades, there have been marked environmental changes in the North Atlantic that may have far reaching consequences for marine predators. Surveys to estimate cetacean abundance took place in 1994, 2005/07 and 2016 in European Atlantic waters, with the primary aim of obtaining robust information to support conservation assessments. We present new results from the 2016 summer surveys (SCANS-III and ObSERVE) on species-habitat relationships and predicted distribution and abundance for eight cetacean species to assess changes since the 1990s. In 2016, eight aircraft and three ships were used to cover an area of approximately 2.1 million km^2. Data were collected using the circle-back method for aerial and two-team tracker method for ship survey to account for animals missed on the transect line. A total of >70,000 and >10,000 km were surveyed by air and ship, respectively, generating more than 4,500 sightings of 19 cetacean species. The data were modelled as a function of a range of static (e.g. depth, slope), physical (e.g. SST, absolute dynamic topography) and biological (e.g. chlorophyll a, primary productivity) variables using Generalised Additive Models. The best models were chosen using a robust model selection protocol, and the results were compared with those from the previous surveys. Overall, for harbour porpoise, bottlenose, white-beaked, common and striped dolphins, and pilot, fin and beaked whales, the predicted distributions in 2016 were similar to those from 1994 and 2005/07, despite high variation in estimated abundance for some species (bottlenose, common and striped dolphins). This broad conclusion of relatively little change in summer distribution should be interpreted cautiously. It is important to continue collecting long-term, large-scale, high quality data sets to be able to assess how cetacean species are responding to changes in marine systems, including ocean warming.

The distribution and vocal behavior of the Atlantic white-sided dolphins (Lagenorhynchus acutus) in northern Norway

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The distribution and behavior of the Atlantic white-sided dolphins (*Lagenorhynchus acutus*) are understudied in Norway. We have conducted boat surveys and underwater sound recordings in the Vestfjorden, northern Norway. 70 sightings of *L. acutus*, mainly from June to October, were recorded including Photo-ID cataloging of 55 individuals and 29 re-sightings of the catalogued individuals. Our study indicates a stronger presence of *L. acutus* than previous reported in northern Norway. The dolphin's vocalizations consisted of clicks (1-24 kHz), buzzes, calls, whistles, of which 82.91% were stereotyped whistles. Four vocalization categories (clicks, buzzes, calls and whistles,) of *L. acutus* were quantified during four surface behavioral categories (foraging, milling, socializing and traveling). We investigated if specific vocalizations of *L. acutus* were associated with specific behavioral categories and if vocal behavior changes with activity. In general clicks were the most commonly recorded vocalization (97.8-99.5%), followed by whistles (65.4-76.2% when clicks are omitted). Clicks were consistently associated with foraging (99.2%) and milling (99.5%); whistles were consistently associated with socializing (70.2%) and milling (76.2%); calls were consistently associated with traveling (32.4 %); and buzzes were absent during milling and varied (0-14.1%). Further our observations indicate a larger distribution and variety of vocalizations associated with different behaviors within this population.

Impacts of sand-dredging on the critically endangered Yangtze finless porpoise in its major inhabited lake

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With China's rapid economic growth and the great demand of sand for construction, the intensity of sand-dredging has risen sharply in the past decade in the two biggest lakes (Dongting Lake and Poyang Lake) adjoining to the Yangtze River. As these two lakes are inhabited by almost half of the wild Yangtze finless porpoise (YFP) population, sand-dredging is posing a significant threat to the survival of this species. We examined the scale and intensity of sand-dredging activities in Dongting Lake from 2000 to 2019 and investigated their potential impacts on the YFP. We examined more than 200 qualified Landsat images from 2000 to 2019 to map the scales and calculate the intensities of sand-dredging through Google Earth Engine. We also calculated the densities of vessels waiting for sand-loading in the lake mouth area. Combining with the results of nine population surveys conducted between 2006 and 2019, our analysis showed that sand-dredging has a significant adverse impact on the population and distribution of the YFP. First, the population trend of the YFP is negatively correlated with the sand-dredging intensities. The population estimations were relatively low from 2009 to 2015 while the sand-dredging was intensified since 2009 but ceased in early 2017 due to a strict sand-dredging ban. Second, the distribution of the YFP is negatively correlated with the distribution of sand-dredging activities. The regions with intense sand-dredging activities from 2012 to 2016 have lower sighting records of the YFP. Third, the vessels in the lake mouth area have almost blocked the entire region since 2012, making the river-lake movement of the species impossible. Therefore, we stressed that the current sand-dredging ban in Dongting Lake should continue and we strongly advice to strictly regulate the vessels in the lake mouth region to restore the river-lake movement of this species.

Collaborative evaluation of a booming spinner dolphin watching industry in the Philippines, using social and dolphin behavioural surveys to inform policy development

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Visitation to the small island of Panglao doubled from ~300,000 visitors in 2015 to ~600,000 visitors in 2016. An international airport with capacity for two million visitors, annually, opened in late 2018. Increasing tourist numbers has led to a proliferation in backyard built boats that facilitate an unregulated dolphin watching industry. To support local government in developing their ordinance for sustainable dolphin watching, we undertook a holistic investigation to describe the activity; understand operator and visitor perceptions; and infer dolphin habitat use and disturbance. Between February and July 2017, we collected 409 structured visitor questionnaires; 117 structured operator interviews; and partook in 10 tours, assessing them against sustainable nature-based tourism criteria. We undertook 32 boat-based surveys, recording before-during-after dolphin behaviour continuously and at five-minute intervals, as well as vessel number, spread, approach type and proximity to dolphins. Operators targeted ~150 spinner dolphins in nearshore waters early in the morning at the start of island hopping trips, with a 95% encounter rate. The predominant behavioural state was resting but events were erratic, with avoidance response and evasion increasing with increased boat number, proximity and aggressive driving. Interactions involved up to 53 boats; 20 within 20 m, another 33 within 50 m, of dolphins. Eighty per cent of boatmen indicated that they drive within 20 m of dolphins. Most enjoy working in tourism, want to make visitors happy, and don't want to cause harm to dolphins but felt pressured to be nearer when more boats were present. Visitor satisfaction and perception varied broadly but expectations were often not met and the majority were dissatisfied with high number of boats present. Conservation benefits are lacking as no visitor interpretation is provided. Decoupling dolphin watching from island hopping, using larger boats and initiating a rotation system are considerations for policy development that would achieve fewer boats.

Abundance and trends of narwhals wintering in polynyas around Greenland

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Polynyas are important wintering areas for marine mammals and the North Water Polynya (NOW) in Northwest Greenland is known to be the most biologically productive polynya in the Arctic. Whilst the NOW has been a reliably recurrent and high-production ecosystem for recorded history, the Northeast Water Polynya (NEW), which forms each spring over the continental shelf of Northeast Greenland, is recurring in different sizes between years. A northward coastal current interacts with a persistent shelf ice barrier under which water can flow but that retains ice floes and therefore protects the NEW area from ice advection. The Scoresby Sound Polynya Ecoregion (SSP) includes the world's largest fjord system with an associated polynya off shore in winter.

Narwhals winter in all three polynyas around Greenland and we investigated abundance and distribution of narwhals by visual aerial surveys involving double observer platforms at the wintering grounds in April 2014 (NOW) and April 2017 (NEW) and at the summering ground in August 2016 (SSP).

Narwhal density and abundance was estimated using a Hidden Markov Model (HMM) approach. This involves first estimating the parameters of a HMM for whale availability, using time-depth recorder data, and then integrating these HMMs with the aerial survey line transect data, using both perpendicular and forward distances to detected whales to estimate detection probability. Narwhals in high numbers were observed in the NOW whereas the abundance of narwhals in the NEW and SSP were low. Trend analysis show a stable population of narwhals in the NOW while no trend is possible for narwhals in the NEW. There is a long-term decline in the population that summer in the SSP.

Allied whale UME stranding analysis on the northern Maine coast

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The goal of this study was to complete a comprehensive mapping analysis of seal stranding events documented during the Northeast Pinniped Unusual Mortality Event (UME) along the coast of Maine. Under the United States' Marine Mammal Protection Act, an UME is "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." Data for this study were collected by Allied Whale's Marine Mammal Stranding Response Program at College of the Atlantic. The environmental factors analyzed in ArcGIS Pro included geology, weather conditions, substrate, and coastal population. These geographic and environmental conditions were mapped to observe how each factor may affect documentation and reporting of a stranding event. Our main focus of this study was on the variance in surficial geology present at stranding locations in northern Maine. Marine mammal species habitat use patterns and human population size were compared with surficial geology and weather patterns in order to theorize where hotspots of future strandings may be found. We found that stranding events most commonly occur on favorable surfaces, either due to human overlap with marine mammals or due to the unique condition of the animal, and therefore could assist in understanding where significant numbers of future strandings occur. This study focuses on critical locations for marine mammal strandings to provide location information to prioritize close monitoring for future strandings. We have found a high preferability to ledge and mud flat environments in pinniped strandings. Approximately 50% of all pinniped strandings in 2018, most of which were associated with the UME, were found on ledges or mud flats. The remaining 50% were found on seventeen various substrates. A continuation of the study will be conducted to compare substrate preferability of pinnipeds from 2008 to 2018.

An evaluation of machine learning algorithms for detecting ice seals in images collected during aerial surveys

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High-resolution digital images obtained from aircraft or satellites are rapidly replacing visual sightings surveys as the basis for enumerating many marine mammal populations. Collecting images, rather than relying only on in-flight sightings, gives us a permanent record from a survey and the flexibility to use different approaches for detecting seals while eliminating elements that make visual in-flight detection

challenging (e.g., observer fatigue, camouflaging, and weather conditions). We have successfully used aerial infrared (thermal) images to detect warm-bodied Arctic seals ("hotspots") against the cold background of sea ice, and paired high-resolution color imagery to identify the hotspot to species. This method produces millions of images for surveys conducted in ice seal habitat (such as in the pack ice of the Bering or Chukchi Sea in spring) and requires the automation of the detection and identification processes for economy of labor. Through collaborations with private industry, we developed several deep learning algorithms using an annotated training imagery set and evaluated the algorithms' performance using a separate test imagery set. Here, we present an overview of each approach and an evaluation of how well these algorithms work for detecting ice seals using recall (a measure of how many of the seals were detected), precision (a measure of how many of the detections were actually seals), and F1 scores (a measure of accuracy that balances the importance of recall and precision). Preliminary testing of algorithms has yielded successful detections of ice seals, and the automated methods will reduce image processing labor by 1 to 2 orders of magnitude relative to manual inspection of the images by experienced observers.

Stealthy foraging: Dolphins can discriminate among marine species using vision alone.

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Prey capture requires stealth, however, broadband echolocation clicks may alert prey to odontocetes' interest. Using vision to identify prey would enable dolphins to remain silent, but little is known about their ability to distinguish among other ocean inhabitants visually. Will vision serve? We investigated the ability of 3 adult male bottlenose dolphins in a 5.8-million-gallon mixed-species salt water habitat to discriminate among 35 marine species of teleosts, elasmobranchs, and reptiles in a matching-to-sample task: Dolphins viewed a still photo or video sample (e.g., a permit) in one underwater window located 4 m below the surface and chose from among 3 video alternatives (e.g., a swimming look-down, permit, or palometa) in an adjacent window presented in 18-trial sessions balanced for sample identity and alternative position. Observers naïve to the presented sample identified the dolphin's choices. In later sessions, stimuli projected on the window alerted the dolphins to the opportunity to engage in these trainerless, self-initiated "foraging" sessions; if dolphins chose to participate, correct matches led to food fish appearing at the water's surface. The dolphins successfully discriminated 30 3-alternative sets (5 sessions per set; M=81.20%, SD=10.04%) and chose to participate 92.16% of the time with an average latency to response to the first sample of each session of 12.09 sec. During sessions, educators explained the science and delivered conservation messages (e.g., effects of ocean noise) to guests. Our approach provided the dolphins with choices to engage in naturalistic behaviors in the form of foraging sessions, our guests with conservation and science education, and scientists with data: Dolphins can use vision alone to discriminate both still and mobile marine species. This cognitive/perceptual capacity is necessary for dolphins to rely on vision as part of a successful foraging sequence. Vision's role in natural prey detection should not be discounted in management decisions.

Quantifying behavioural responses of minke whales to sonar activity during Navy training exercises

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Data from passive acoustic monitoring (PAM) of navy training ranges can be used to test predictions of marine mammal responsiveness to naval sonar established through experimental behavioural response studies. Minke whale (*Balaenoptera acutorostrata*) vocalizations were detected, classified, localized and associated into individual tracks from data collected on bottom mounted hydrophones on the U.S. Navy's Pacific Missile Range Facility, Hawaii. Data were analyzed from before, during and after naval undersea warfare training activities in February 2014 (126 tracks) and 2017 (203 tracks). Speed and turning angles were derived for each track, and tracks were aligned with relevant contextual variables (environmental, ship and sonar-related). Firstly,

the spatial distribution of tracks was modelled using latitude, longitude, depth, year and phase (Before, During, After) as covariates. It was found that, as well as inter-annual variability across all phases, the distribution of calling whales changed in both years, with fewer tracks in the vicinity of the centre of ship activity in the During phase compared with Before. Secondly, Generalized Estimating Equations (GEE) were fit to speed and turning angle with year, phase, and time to and since the nearest sonar exposure as covariates. In both years speed increased and turning angle decreased with time since the start of the During phase. As the data are from PAM, it is unknown whether the change in spatial distribution of tracks across the range is a result of whales moving away from the range or ceasing calling, or perhaps a combination of both. The expectation from experimental studies is that minke whales will exhibit avoidance in response to naval sonar. The GEE results indicate a horizontal movement response, but to confirm whether this is an avoidance response will require combining the whale track data with the ship/source position data.

Renewals of incidental harassment authorizations under the U.S. Marine Mammal Protection Act: Process streamlining.

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To provide compliance with the U.S. Marine Mammal Protection Act (MMPA), which prohibits all "take" of marine mammals including harassment unless authorized or exempt, the National Marine Fisheries Service (NMFS) issues Incidental Harassment Authorizations (IHAs) for U.S. citizens conducting activities that are expected to harass marine mammals, provided certain findings can be made and mitigation, monitoring, and reporting requirements are included. These IHAs can take five to eight months for the agency to process, and even longer in certain circumstances. NMFS has begun implementing an expedited process (with processing completed in approximately 60 days) whereby the agency may, on a case-by-case basis, issue a one-year Renewal for IHAs provided certain conditions are met and the activities covered by the proposed Renewal consist of either: 1) *another* year of identical, or nearly identical, activities as were covered by the initial IHA (or a subset of those activities) or 2) a subset of the activities covered by the initial IHA because the originally planned activities were not completed within the effective dates of the initial IHA and are planned for completion under the proposed Renewal. This expedited process is designed for application to simple, relatively low-impact projects with little to no uncertainty regarding the impacts of the activity on marine mammals, including type and amount of expected take. Here, we describe the conditions that must be met in order for an IHA Renewal to be issued, the process for Renewal issuance, and the materials that an applicant should submit when requesting an IHA Renewal.

Assessment of disturbance to Hawaiian monk seals and birds in the Northwestern Hawaiian Islands by a hexacopter UAS

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Unoccupied Aircraft Systems (UAS) have great potential for Hawaiian monk seal (*Neomonachus schauinslandi)* conservation research by allowing scientists to survey seals with greater efficiency and at difficult to reach locations. UAS may also have drawbacks, including disturbance to target and non-target species which could cause stress and preclude successful research objectives. The objective of this study was to determine the extent to which an APH-22 hexacopter would disturb seals or birds in the Northwestern Hawaiian Islands. Seal behavior was recorded before and during flights at altitudes of approximately 50m, 30m, and 10m. Results showed that disturbance to seals was minimal. 81% of seals did not respond to the APH-22 above 25m. Above 40m, 12% of seals responded to the APH-22 with a raised head. Between 25 and 33m, 25% of the seals responded, with one seal flushing and subsequently returning to the beach. Between 9 and 14m, 67% of seals responded, most with a raised head. Disturbance to birds commonly found in important areas for seal surveys was recorded before, during, and after flights to determine whether UAS surveys would present risks to non-target species. Bird disturbance varied by species. Noddies (*Anous* spp.) and boobies (*Sula* spp.) most often flushed from the beach, but generally returned within minutes. Great frigatebirds (*Fregata minor*), white terns (*Gygis alba*), and several species of boobies approached the APH-22 during flight, but none made contact. This study showed minimal seal and bird disturbance from the APH-22, suggesting that this

tool can be used safely for Hawaiian monk seal conservation research. Future studies will continue to assess the impact that UAS have on target and non-target species.

Male Risso's dolphins (Grampus griseus) maintain a multi-level network of intra-alliance associations.

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Multi-level associations between male individuals have been observed in a few mammal species outside humans. In toothed whales, only male bottlenose dolphins are presently known to cooperate at more than one hierarchical level. The social structure of adult male Risso's dolphins (*Grampus griseus*) is organized in highly stable clusters, ranging from 3-12 individuals. These features offer potential for an in-depth intra-group analysis. Here we introduce a new method for data collection using a drone and social network analysis focusing on a group of thirteen wild-ranging male Risso's dolphins. This enabled us for the first time to continuously identify and record the detailed behaviour of every individual throughout the focal group follow. A total of twenty-two separate drone flights were operated in July and August 2017, during 8 distinct surveys. Synchronized surfacing behaviour was scored from drone footage for all individuals, and taken as an indicator of association stability, which was subsequently analysed focusing on relative distance over time and group-position. We recorded a total of 2,337 single breathing events, out of which 590 synchronous dyads were identified: 466 pairs (20%), 20 trios (0.9%), 6 quartets (0.3%) and 1 octet. Using social network analysis and the Dynamic Time Warping method, we detected clear synchrony partner preferences, confirming four strongly associated pairs and one persistent trio. Most pairs were found stable during a single survey but variable among surveys. A second level of association was discovered, dividing the pod in three subgroups. Interestingly, we found a correlation between lower synchrony rates and rear position for two weakly associated subgroups, whereas the third subgroup (possibly dominant males), revealed a correlation between higher synch rates and front/middle positions. Future studies will focus on drivers of Risso's dolphin male alliance formation.

Entanglement survivors; Assessing the impact of non-fatal entanglements on Scottish minke whales.

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Marine mammal entanglement in fishing gear is a global problem, and a growing concern in Scottish waters. For minke whales (*Balaenoptera acutorostrata*), it has been identified as the single largest cause of death, and up to 22% of live animals show some entanglement evidence (Northridge et al. 2010). In June 2018, six organisations partnered to form the Scottish Entanglement Alliance (SEA) to better understand the scale, impact and risks of entanglement in Scottish waters from a conservation, welfare and economic perspective.

As part of this work, the Hebridean Whale and Dolphin Trust (HWDT) aims to provide an updated assessment of the proportion of minke whales that experience non-fatal entanglements. To achieve this, photo-identification data collated by HWDT between 1990 and 2018 have been analysed to assess the number of animals that show evidence of entanglement. From 485 encounters, 235 individual whales were identified, adding an additional 103 whales to the catalogue since it was last evaluated in 2008 (Northridge et al. 2010). Initial analysis indicated that 5.5% of animals showed scars potentially resulting from entanglements.

Laser photogrammetry, which positions two reference points on the animal's body to allow measurements to be taken, is also being used to classify scars from interactions with fishing gear. Preliminary analysis of the laser photogrammetry data shows that it is possible for this method to be used to measure scars, but the number of successful captures has been low, primarily due to weather conditions interrupting the laser beams reach.

The analysis of this long-term dataset allows some of the previously identified knowledge gaps to be addressed (e.g. quantifying accumulation rates of marks and scars), and will contribute to the assessment of the rate and risk of non-lethal entanglement in Scottish waters. This is crucial to

identify suitable mitigation measures, and inform management and conservation measures.

Seasonal changes in body condition for spotted, ringed, and bearded seals

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As high-latitude species, Arctic seals manage considerable changes in environmental and ecological conditions annually. They depend upon sea ice for rest, predator avoidance, and to carry out key life-history processes; however, this critical substrate is declining rapidly in persistence, thickness, and extent. During times of nutritional stress and/or when energy demands exceed energy intake, seals can mobilize lipids from their insulating layer of blubber to fuel metabolic processes. Thus, blubber thickness can vary greatly throughout the year and is often used as a metric of body condition. Here, we used the traditional truncated cones method to examine fine-scale changes in blubber mass for three Arctic seal species. Subjects included 4 spotted (*Phoca largha*), 3 ringed (*Pusa hispida*), and 1 bearded (*Erignathus barbatus*) seal. Energy intake was allowed to vary naturally and seals were trained to participate in data collection. Photogrammetric and direct morphometric measurements were collected weekly at defined locations along the body. Blubber depth was measured at the same locations using a portable ultrasound machine. All measurements were averaged monthly for a minimum of 1 year and used to determine body composition. On average, spotted seals experienced a 43% annual change in blubber mass, although this value was highly influenced by one individual (range 27% - 72%). Ringed seals incurred a 19% annual change in blubber mass (range 13% - 26%), while the bearded seal exhibited a 12% change. In spotted and ringed seals, blubber mass decreased prior to and through the molt, followed by an increase post-molt; this relationship was less defined for the bearded seal. Our data suggest physiological and environmental parameters are important in driving body condition patterns in these species. Ultimately, longitudinal assessments of body condition can be used to identify critical periods when seals may be most vulnerable to disturbance or environmental change.

Risk balancing by a marine mammal: Man-made noise reduces the foraging success of seals.

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Foraging theory predicts that individuals should attempt to maximise their energy gain by foraging in patches with high food densities. However, animals faced with a choice between a rewarding food patch which has a high degree of risk associated with it, and one that is both less rewarding but less dangerous, should exhibit foraging decisions that reflect both the degree of risk involved and the energetic advantage. Sounds from anthropogenic sources can affect marine mammal foraging behaviour, yet evidence of the effects on foraging success in these species is lacking. We measured the influence of anthropogenic sounds (pile driving, a tidal turbine, and a silent control) on grey seal behaviour within a simulated foraging scenario and investigated the influence of food availability and perceived risk. Seals were given access simultaneously to two underwater 'food patches' in an experimental pool where fish were delivered at controlled rates to simulate a low reward (LRFP) and a high reward (HRFP) food patch. Acoustic playbacks were made using an underwater speaker above one of the food patches (randomised during the study), and three foraging metrics (foraging duration, foraging effort allocation between the food patches, and foraging success) were measured. Foraging success was highest during silent controls and was similar regardless of speaker location (LRFP/HRFP). Under the tidal turbine and pile driving treatments, foraging success was similar to the controls when the speaker was located at the HRFP but was significantly reduced (~16-28% lower) when the speaker was located at the LRFP. Results suggest that the foraging decisions by the seals reflect a risk/profit balancing approach. In response to a perceived risk associated with the anthropogenic sounds, seals apparently showed avoidance of the sounds when the energetic rewards were low but not when the rewards were high.

Photographic capture–recapture analysis reveals a largely non-resident population of

Indo-Pacific bottlenose dolphins (Tursiops aduncus) inhabits coastal waters off the North West Cape at World Heritage listed Ningaloo Reef Marine Park, Western Australia.

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Studying the demographic parameters of open populations of wide-ranging delphinids is difficult. This challenge increases when studying open populations containing a high proportion of non-resident individuals that use the study area for short periods. Failure to account for these individuals can lead to biased estimates of population demographic parameters. In this study, we used site fidelity indexes and capture-recapture models to estimate the site fidelity and abundance of an open population of bottlenose dolphins inhabiting the coastal waters off the North West Cape of Western Australia, located within the World Heritage listed Ningaloo Coast and home to the Ningaloo Marine Park. Photo-identification data was collected during boat-based surveys off the North West Cape between 2013 and 2015. A standardised site fidelity index (SSFI) estimated extremely low site fidelity (SSFI = 0.019) at the population level. Agglomerative hierarchical clustering of individual re-sight rates showed that 58% of individuals identified exhibited low levels of site fidelity, indicating that most individuals in this population are non-resident. POPAN modelling estimated a super-population size of 309 (95%CI: 261-356) individuals over the study period. A maximum likelihood transient model which considers both resident and non-resident individuals in the population, estimated a resident population of 148 (95%CI: 127-169) individuals and a super-population of 398 (95%CI: 347- 449) individuals. These models indicate that a moderately large population of bottlenose dolphins inhabits the waters off the North West Cape. The large number of both resident and non-resident bottlenose dolphins found throughout the study area suggest the coastal waters off the North West Cape are used frequently by this species. The substantial number of non-resident individuals and low site fidelity suggest, however, that bottlenose dolphins occupy a much larger area and future studies and conservation decisions should consider neighbouring waters within and outside the marine park.

Arctic marine mammal ecology and health: Finding common ground between conventional science and Indigenous Knowledge to track arctic ecosystem variability.

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Arctic marine mammals respond to, and thereby reflect, changes in Arctic ecosystems that are important both to practitioners of conventional science (CS) and to holders of Indigenous Knowledge (IK). Although often seen as contrasting approaches to tracking ecosystem variability, when CS and IK are combined they can provide complementary and synergistic information. Despite exceptions, ecosystem-focused CS is often spatially broad and time shallow (1000s km, decades) while IK is comparatively narrow spatially and time deep (10s km, centuries). In addition, differences in how information is gathered, stored, applied and communicated can confound information integration from these two knowledge systems. Over the past four decades, research partnerships between CS practitioners and IK holders have provided novel insights to an Alaskan Arctic marine ecosystem in rapid transition. We identify insights from some of those projects, as they relate to changes in sea ice, oceanography, and more broadly to marine mammal ecology and health. From those insights and the protocols of existing community-based programs, we suggest that the strong seasonal cycle of Arctic environmental events should be leveraged as a shared framework to provide common ground for communication when developing projects related to marine mammal health and ecology. Adopting a shared temporal framework would foster joint CS-IK thinking and support the development of novel and non-linear approaches to shared questions and concerns regarding marine mammals. The overarching goal is to extend the range and depth of a common understanding of Arctic marine mammal health and ecology during a period of rapid ecosystem alteration. The current focus on CS-IK co-production of knowledge and recent inclusion of marine mammals as essential variables in global ocean observatories makes this an opportune time to find common ground for understanding and adapting to the rapid changes now underway in Arctic marine ecosystems.

Subcellular distribution and metalloprotein detoxification of titanium, a contaminant of emerging concern, in Pontoporia blainvillei and Steno bredanensis from southeastern Brazil.

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Titanium (Ti) is a contaminant of emerging concern used in personal care products in the form of nanoparticles (TiO_2), which can bioaccumulate and biomagnify along trophic webs, eliciting deleterious effects. Ti content and detoxification data for aquatic organisms is scarce in general, while no assessments concerning marine mammals are available.Therefore, subcellular Ti distribution and detoxification were assessed in endangered *Pontoporia blainvillei* and data-deficient *Steno bredanensis* specimens from southeastern Brazil, in order to assess intracellular and, thus, bioavailable Ti contamination for the first time in both species. Kidney, muscle and liver samples were heat-extracted and insoluble (ISF), thermos-labile (TLF) and heat-stable (TSF) fractions were obtained. The TSF also contains metallothionein (MT), a metal-detoxification protein that binds to metals for subsequent excretion. MT concentrations were spectrophotometrically determined, Ti was determined by inductively coupled plasma mass spectrometry (ICP-MS) and Ti TSF detoxification was characterized by high performance liquid chromatography (HPLC) coupled to ICP-MS. Ti-metalloprotein detoxification was observed in kidney (~10%), liver (~15%) and muscle (~25%) TLF and TSF, respectively in *P. blainvillei*, while ISF Ti ranged up to 50%. All *S. bredanensis* tissues exhibited Ti detoxification, although ISF levels were high (~75%), establishing a differential Ti detoxification pathway mostly unmediated by MT. A Principal Component Analysis verified Ti-MT associations in both species, confirming TiO_2 contamination in Southeastern Brazil, since Ti binds to MT only in nanoparticle form. In addition, high oceanic TiO_2 diffusion was noted, due to oceanic currents and/or differential prey distribution, as *S. bredanensis* lives in offshore waters further from the coast than *P. blainvillei* but still presented MT-Ti correlations. Ti was associated to reduced glutathione (GSH) in both species, indicating possible Ti-GSH binding and detoxification. These findings indicate that the TSF is a valuable tool concerning Ti detoxification assessments in cetaceans, which may be applied to conservation efforts.

From phocine distemper to avian influenza: An ecological perspective on immunogenetic diversity of two sympatric pinniped species.

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Gray (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) are sympatric species that inhabit the North Atlantic and have been subject to mortality events from disease outbreaks, particularly phocine distemper and avian influenza virus. Across mortality events, gray seals tend to be more immunologically robust, exhibiting a higher survival rate. This difference could be explained by various ecological factors impacting rates or direction of selection in parts of the genome related to the immune system. These factors could include haul-out site density, habitat, and degree of inter/intraspecies interaction. This research aims to compare selection for genetic diversity within the Major Histocompatibility Complex (MHC) class I among gray and harbor seals. The MHC is a group of genes that allow the immune system to recognize foreign pathogens, with class I responding to viral pathogens in particular. Possessing greater genetic diversity at this region can be tied to greater immunocompetence. Due to its duplicated nature, MHC class I diversity has been challenging to evaluate across multiple gene regions at a population scale, but recent advances in sequencing technology enable high-throughput genotyping of complete MHC regions. In this study, MHC diversity across multiple class I exons is assessed using amplicon sequencing to compare the degree of copy number variation, number of alleles and amino acid sequence diversity between species and among populations. We test the hypothesis that gray seals will exhibit greater diversity consistent with their higher survival rate during viral-induced mortality events. These analyses will be performed on tissue biopsy samples from harbor seals by-

caught in the Northeast US and live, weaned gray seal pups from three locations in the Northwest Atlantic. This research aims to address how differences in ecology drive evolutionary differences in two closely related species and investigate how sympatric species evolve in the face of natural stressors.

Persistent organic pollutant burdens in blubber of eastern North Pacific gray whales (Eschrichtius robustus) and the influence of life history parameters.

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Bioaccumulation of persistent organic pollutants (POPs) in lipid-rich blubber tissues puts marine mammals at risk of developmental dysfunction, reproductive failure, and immunosuppression. Research conducted in the 1960s-1990s reported POPs in gray whales (*Eschrichtius robustus*) but contemporary data were lacking. Here, we report on baseline concentrations of contaminants in gray whale blubber across life history parameters including sex, age, and reproductive status. Blubber biopsies (n=120) were collected from free-swimming whales between 2003 and 2017 along the Pacific coast from southern Canada to Baja California, Mexico. A rare sample collection of 19 mother and calf pairs provide the first direct assessment of patterns of maternal offloading of contaminants in gray whales. POP blubber concentrations (mean ± SEM in ng/g lipid weight) were 226 ± 26 ΣPCBs, 230 ± 35 ΣDDTs, 88 ± 7 Σchlordanes, 74 ± 9 Σpolybrominated diphenyl ethers, and 74 ± 5 Σhexachlorocyclohexans. Overall mean PCB and DDT burdens were found to be lower on average than previously reported for gray whales. Statistical modeling of 20 select compounds revealed significant sex, age, and reproductive status-related POP trends. Immature whales in this study had similar POP concentrations across sexes. Adult males had higher POP burdens than immature males. Female POP burdens varied little across age-groups, with the exception of DDT metabolites and some higher chlorinated PCBs, which were higher in adult females. Significant differences in adult male versus adult female POP burdens for most compounds were attributed to maternal transfer of contaminants during reproduction. Contaminant loads of most compounds were marginally higher in mothers than in calves, further suggesting significant maternal offloading during reproduction. This study provides current POP concentrations in gray whales and enhances our understanding of POP trends across life history stages. Such information should aid in the design and interpretation of contaminant burden monitoring in this protected species.

Physical maturity in bottlenose dolphins (Tursiops truncatus) from Sarasota Bay, FL.

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Physical maturity in cetaceans is defined as when growth ceases and all epiphyses are fused to the vertebral body such that the suture line is no longer visible. Many studies have shown that this is highly variable among individuals and in-depth examinations into fusion variability have been lacking. We analyzed the vertebral columns of 38 (n=22 female; n=16 male) stranded common bottlenose dolphins (*Tursiops truncatus*) known from the well-studied Gulf of Mexico, Sarasota Bay resident community. For each specimen, vertebrae were examined by anatomic region for the degree of fusion on the anterior and posterior side of each centrum and categorized as un-fused (1), fused with open suture lines (2), fused closed

with the entire suture line visible (3), fused closed with partially visible suture lines (4), and fused closed with invisible suture lines (5). An ordinal logistic regression was used to estimate a given joint's degree of fusion probability. The model had fixed effects for an individual's age, number of calves, sex, and sexual maturity and a random effect for joint. Physical and sexual maturity are not synonymous, though often linked. Our results definitively show that age and reproductive status significantly explain an individual's degree of fusion. Sex alone however, had a non-significant effect on fusing. Adult females with fewer calves had higher fusing of the vertebral epiphyses than those with more reproductive experience across multiple ages. The relationship between energetic demands of reproduction vs preconceived definitions of physical maturity is worth examining more closely. The long-term partnership between the Sarasota Dolphin Research Program and the Stranding Investigations Program at Mote Marine Laboratory offers this relationship, as well as genetic findings, to be further examined.

Some like it cold: Targeted temperature range during feeding in narwhals.

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The narwhal (*Monodon monoceros*) is a high Arctic species inhabiting areas that are now experiencing increases in sea temperatures, which together with reduction in sea ice are expected to modify the niches of Arctic marine apex predators. The Scoresby Sound fjord-system in East Greenland is the summer residence for an isolated population of narwhals. The movements of 12 narwhals instrumented with FastLoc GPS transmitters were studied during summer in Scoresby Sound and during winter at their offshore wintering ground. CTD tags on additional four narwhals provided detailed information on the temperature profiles (down to 1000 m) on both the summering (284 profiles) and the wintering ground (263 profiles). Data on diving of the whales were obtained from deployments of 16 Acousonde™ recorders, and 10 satellite-linked time depth recorders deployed from 2010 through 2018. The Acousonde recorders furthermore provided information on the temperature and depth of buzzes during summer. The whales targeted depths between 300 and 500 m in summer. At these depths the preferred areas visited by the whales had temperatures ranging between 0.6 and 2.0 ºC with an average temperature at 300 m of 1.1 ºC (0.6-1.8ºC, SD=0.25). The buzzing activity during summer was focused (10% kernel probability distribution) on depths between 282 and 387 m where the temperature when buzzes occurred was within 0.5-1.0 ºC. In winter the whales targeted depths >500 m where the average temperature was 1.3 ºC (range: 0.7-1.7, SD=0.29). It is unknown if the small temperature niche of whales while feeding is because prey is concentrated at these temperatures and are easier to capture at low temperatures, or because there are restrictions in the thermoregulation of the whales. In any case, the small niche requirements emphasize the sensitivity of narwhals to habitat changes.

Diet analysis of seals in the southern North Sea based on faeces; A comparison between molecular and physical analysis.

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Diet is key to understanding an animals' requirements and its role in the ecosystem. We investigated the diet composition of two seal species occurring in the southern North Sea, the harbour (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), based on their faecal remains. Both species recently grew exponentially, and may play an important role as top predator. The methodology used traditionally is limited to hard parts recovered from excrements, but this method lacks the possibility to detect prey without bony structures or hard parts that did not survive digestion. Analysing fragmented DNA of consumed prey may give a better and broader insight into these seals' diet. This study compares both approaches. For this we used frozen seal faeces samples collected over several years (2011 - 2018) along the Dutch coast. For the hard-part analyses, faeces samples were washed and remaining hard parts were examined and brought to species level. For the DNA extraction, different methods were used to dissolve the faecal samples; Ethanol, water and/or freeze-drying and PBS buffer. Ethanol resulted in the fixation of particles, obscuring the analysis of hard parts. The Qiagen

Fast DNA Stool Kit was used to extract DNA. To identify prey DNA, a ~77 base pair fragment of the 16S mtDNA was used. Since not only fish DNA is targeted, but also other chordate animal species like seals, a blocking primer was added to block (most of) the seal DNA. Next Generation Sequencing was used to sequence all present faeces DNA. By comparing the hard parts with the DNA based analyses we were able to make a (more) complete analysis of the very variable diet of harbour and grey seals living in the southern North Sea, thus obtaining a first insight in their role in the ecosystem.

Risk of collisions between fin whales and marine traffic in the Garraf coastal area, Balearic sea

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Ship strikes are a major non-natural source of fin whale (*Balaenoptera physalus*) mortality in the Mediterranean Sea, as has been proven in the past and possibly pose a sinister threat for the health of this understudied population, or as recent insight suggests, populations. Even though these problematics have already been a focus of a previously done research for a certain part of the Mediterranean, this study focuses on the negative relationship between the fin whale spatial distribution and the trajectory of cargo ships in front of the Garraf Coast, Balearic Sea. This study is a part of a much larger overall and ongoing multiannual research of fin whales frequenting the nutrient rich area of the Garraf coastal waters in the spring season. Using the sightings data that was acquired over the years it was possible to gain insight into the distribution pattern of the whales in the research area, as well as attain data of shipping tracks from cargo vessels that pass through the research area. In addition, local fishermen shared the location of several whale bones from carcasses that they fished out, suggesting possible collision events. By mapping fin whale distribution in the Garraf coastal area against the marine traffic data, this study proves a considerable spatial overlap within this fin whale feeding ground and the marine traffic, exposing that the discussed area is one with a high probability of ship strikes and also locates the most problematic hotspots in the area. Furthermore, the bones found in the area by the fishermen contribute to the notion that ship strikes do happen, but are largely unreported. The presented study serves as a warning and hopefully an instigator for stakeholders to take action towards mitigation policies, as well as a benchmark when those policies begin implementation.

Counting needles in a complex haystack- first abundance estimates for endemic Chilean dolphins in northern Patagonia, Chile

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Southern Chile has the most complex fjord system in the world, and is home to the endemic and apparently rare Chilean dolphin (*Cephalorhynchus eutropia*). No regional or range-wide abundance estimates exit for this species, yet these are imperative to evaluate conservation status and potential effects of anthropogenic threats. Conventional distance sampling methods are not considered suitable due to logistic constraints, the dolphins' patchy distribution, extreme nearshore habitat preference and cryptic behaviour. This study used predictive species distribution modelling to identify focal areas for intensive mark-recapture surveys to estimate abundance of Chilean dolphins in northern Patagonia, where most of Chile's intensive aquaculture farming takes place. Based on the dolphins' predicted occurrence and survey safety considerations we selected eight focal areas spanning the full north-south (41^{o}-46^{o}S) and east-west (72^{o}-73^{o}S) extent of northern Patagonia. We conducted 2-3 week long intensive photo-identification surveys in the focal areas over three consecutive summers (2017-2019) and estimated abundance using closed population mark-recapture (MR) estimators. Encounter rates varied across focal areas from 2-4 Chilean dolphins per 10 km of nearshore survey effort (n=4,100 km). Resighting rates of individuals within focal areas were high (40-80%) with no resightings made between study areas. All dolphin populations were small with (preliminary) MR estimates ranging from 38 to 95 adult individuals (estimates corrected for mark rates). Seven of the 8 surveyed populations were exposed to potential bycatch in aquaculture and fishing operations. Summing population estimates from the focal areas gives 465 Chilean dolphins (95%CIs: 335-621). Assuming the surveyed habitat is representative of the non-surveyed predicted suitable habitat, Chilean dolphins in northern Patagonia seem to number at most in the low thousands. This first region-wide abundance estimate for Chilean dolphins provides a much needed ballpark figure, and the novel local population estimates are sufficiently precise to

guide relevant management and conservation initiatives.

Comparison of the timing abilities of a harbour seal (Phoca vitulina) and a South African fur seal (Arctocephalus pusillus)

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Living in the marine environment might require a precise sense of time as for example tides control access to food as well as haul-out places. Good timing abilities thus seem to be essential for foraging decisions, but also for navigation and orientation when estimating speed of movement for example. A previous study showed, for the first time, the high sensitivity of a phocid, the harbour seal, in discriminating time intervals. In the present study, we compared the harbour seal's timing abilities with the timing abilities of an otariid, the South African fur seal. This comparison seemed essential as phocids and otariids differ tremendously in many respects including lifestyle and habitat and might thus also differ regarding their timing abilities.

The experiments were conducted under constant light conditions inside an experimental chamber. In a two-alternative-forced-choice procedure, the animal was required to discriminate between standard and longer comparison time intervals marked by a white circle on a black background that was displayed for the respective time interval on a monitor. Time difference thresholds were determined for several standard time intervals in the millisecond to second range by a staircase method.

Contrary to our expectation, the timing abilities of an otariid and a phocid are comparable, with mean Weber fractions of 0.1 for the fur seal and 0.13 for the harbour seal. Timing might thus be a fundamental cue for pinnipeds in general to be used in various contexts thereby complementing information provided by the classical sensory systems.

Estimating relative mortality from satellite tracking data: A quantitative approach on Southern elephant seals.

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Satellite telemetry is a powerful tool to study animal movement especially that of cryptic and marine animals but has had limited application in demographic studies. One possibility is that tracking data can provide data on animal mortality at sea. There is always a proportion of tags that fail during the deployment but disentangling animal mortality from simple tag failure is challenging. Southern elephant seals (SES) present as a model species to disentangle these factors due to the availability of large multi-year tracking datasets, detailed demographic information (particularly survival rates) and the demonstrated knowledge that satellite tags deployments don't in themselves influence mortality. A series of survival analyses were performed on satellite tag data from 185 seals from Isles Kerguelen carrying SMRU SRDL_CTD tags between 2005-2018. Of these 76 returned to land while the remaining 107 tags failed at sea, with an overall failure rate of 43% for females and 74% for males. Several behavioural factors were tested to explain this difference, including habitat use, foraging behaviour and dive characteristics, but none were influential. We included natural mortality, based on known rates for these age classes, as an offset in models to estimate technical tag failure. We then used this failure rate to contrast animal mortality rates in years of good and poor foraging conditions (based on SAM), and found that animal mortality was higher in poor foraging years for females but not sub-adult males. This demonstrates the ability of satellites tags to estimate relative survival rates.

Habitat use and behavior of satellite tagged humpback whales off Kauai

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A multi-year satellite tagging effort was conducted on humpback whales off the island of Kauai from 2017-2019. Nineteen whales were successfully tagged, with tag durations lasting 1.6 – 12.3 days. All seven whales tagged in 2017 transited west to the island of Niihau after being tagged; six of the

whales continued traveling northwest following islands and seamounts, while one began traveling directly north from Niihau. In 2018, four of the six tagged whales also traveled west to Niihau and on to the closest seamounts, while one animal traveled to Oahu and another animal started traveling to Oahu but then went to Niihau. Finally, in 2019 one animal traveled west to Middle Bank before turning around and returning to Niihau; one animal remained close to Niihau; one animal remained close to Kauai; and a female and primary escort from a competitive pod stayed together for at least four days while traveling to Oahu. During this field effort, the location, group size, and group behavior were recorded for all encountered humpback whales. A habitat use analysis was conducted on all encountered groups to determine if different social groups occurred in specific habitats or if they were randomly encountered in a variety of habitats. For example, mother/calf pairs were typically encountered in nearshore, shallow waters on the southwest side of Kauai, while stationary dyads were often encountered in shallow water off the west side. Variables such as Julian date, latitude and longitude, water depth, distance from shore, and the number of other animals in the area were included in a Generalized Estimating Equation of group behavior. In addition, the social role and behavior of the tagged animals were examined to determine if the habitat or social role in which the tagged whales were encountered was related to where the animals traveled once tagged.

In vivo measurements of ringed seal (Pusa hispida) lung volumes: Insights from biomedical imaging.

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Pinnipeds rely on blood, muscle, and lung oxygen stores to support breath-hold diving. Defined by impressive blood volumes, hemoglobin concentrations, and myoglobin content, pinnipeds have a greater capacity to store oxygen in their blood and muscles than their terrestrial counterparts. Thus, these parameters are more commonly the focus of comparative physiological research, with lung structure and function less well studied. Deep diving pinnipeds rely heavily on blood and muscle oxygen stores while diving and collapse their lungs at depth to avoid tissue trauma and pressure related injury. More shallow diving pinnipeds may not fully collapse their lungs on routine dives, and likely rely on lung oxygen stores to a greater degree. Ringed seals (*Pusa hispida*) are among the smallest phocids. They are relatively shallow divers that exhibit short dive durations (typical dives < 100 m and < 8 min), and may rely on lung oxygen stores to a greater extent than other phocids. Currently, there are few studies aimed at understanding how respiratory control and lung oxygen storage is regulated in living marine mammals. Most studies rely on postmortem excised lungs to estimate total lung volume. In this study, we used high-resolution CT scans to provide the first in vivo measurements of total lung volume in ringed seals (n=5) ranging in age from 5 months to two years. All seals were anesthetized and intubated for scheduled veterinary procedures. Full body scans were obtained in 2.5 mm sections at a range of lung pressures (0, 30, and/or 37 mm Hg). By determining total lung volumes from 3-dimensional models of air spaces in living animals, we advance current understanding of diving lung oxygen stores. Further, these data can be combined with previously established estimates of blood and muscle oxygen stores to evaluate overall diving capacity and constraints in this species.

High-frequency masking noise decreases echolocation performance of harbour porpoises.

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Vessel activity is widespread in the marine environment, emitting broadband noise with potential impacts on marine mammals. Vessel noise can extend into frequency ranges that overlap with echolocation signals of small toothed whales, thereby posing a risk for biosonar masking. Masking can decrease their ability to decode echo information, crucial for navigation and foraging. To address that potential problem, we tested whether high frequency noise at realistic vessel noise levels can mask the echolocation performance of harbour porpoises (*Phocoena phocoena)*. Two trained and free-swimming porpoises wearing a multisensor tag (DTAG) were tasked with discriminating between two targets by echolocation, mimicking the ecologically relevant scenario of a foraging toothed whale. At the same time they were exposed to third-octave band limited noise at 2 kHz (control

band, 122-128 dB re 1µPa RMS) or 125 kHz (echolocation band, 105-111 dB re 1 µPa RMS). Custom-built hydrophones were attached above each target continuously recording sound. We conducted 392 trials and show that porpoises increase median click source levels by 4-17 dB when exposed to noise within their echolocation range, suggesting a compensatory mechanism to cope with masking. Despite this, both animals were still significantly poorer at discriminating the targets during these trials, demonstrating their inability to compensate sufficiently to alleviate masking impacts. In comparison, the porpoises maintained their click source levels and performance when exposed to control noise. We conclude that relatively low levels of high-frequency noise, such as from cavitating vessel propellers, can cause masking of porpoise echolocation and that compensatory mechanisms evoked by the animals are insufficient to maintain echolocation performance. As a consequence, high frequency components of vessel noise may have negative fitness impacts on porpoises and other small toothed whales, and we therefore emphasize that high frequency vessel noise effects are included in marine management.

Impact of climate variability on the abundance of gray whale (Eschrichtius robustus) in Ojo de Liebre Lagoon, Baja California Sur, Mexico.

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It has been observed at the end of the last century and during the first decade of the present that the abundance and distribution of gray whales in their wintering grounds is related with sea ice extent in their feeding grounds. Changes in the sea surface temperature (SST) have also been reported in their breeding grounds due to El Niño/a events. For that reason, the goal of the present work was assess the impact of climate variability on the population of gray whale that used Ojo de Liebre Lagoon (OLL) in the past 15 years, and evaluate the occurrence of the described patterns in the past. For that, we made correlations and regressions analysis between gray whale censuses in OLL and the environmental variability in their breeding grounds in the coast of the Baja California Peninsula and their feeding grounds in the Arctic (Bering, Beaufort and Chukchi Seas). During these 15 years, the relationship between ice extent in Bering Sea over the other Arctic grounds as well as production of calves has been observed again (*RSpearman=-0.63, p<0.05*). This relationship shows that a lesser amount of ice at the Bering Sea in the summer increases the production of calves the following winter, confirming the importance of this region as feeding ground for the pregnant females. There is also a meaningful relationship between sea ice extent at the Beaufort Sea in October, the northernmost feeding ground, and the date of the maximum peaks of abundance within OLL (*RSpearman=-0.79, p<0.05*). This relationship suggests a delay in the migration date when there is little ice in the Beaufort Sea and vice versa.

Early development of in-air and underwater sound production in harbour seals (Phoca vitulina)

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Harbor seal pups are unique among phocid seals in their rapid adaptations for swimming and diving. They are known to produce both in-air and underwater calls to keep in contact with the mother during the lactation period. We studied the acoustic development of their vocalizations both in air and underwater through simultaneous hydrophone, microphone and video recordings of two seal births, one female and one male, in the outdoor facility at Fjord&Bælt, Denmark. The pups made their first in-air vocalizations 1-3 min after birth. They started to move around 13-25 min and both went into the water 39 min after birth and almost immediately started diving. Their first underwater vocalizations were heard 60-162 min after birth, or 21-123 min after first entering the water. Most sounds were heard during the first day post-partum, and for all days recorded, most sounds were produced underwater. The in-air and underwater sounds resembled one another, but also showed differences in terms of frequency content and sound intensity. The mothers only produced very infrequent sounds in air and probably never under water. This shows that harbour seals rapidly

develop their abilities to produce sounds both in air and underwater, and that they use the sounds to stay in contact with their mother. The fact that they predominantly produce underwater sounds and that they enter the water very rapidly after birth compared to other seals indicate that not only do their diving abilities develop at a very early age, but so does also their sound production and probably also their hearing abilities. This has important implications for understanding not only how sounds are used between mothers and pups during the lactation period, but also how anthropogenic noise may affect the bonds between the mother and the pup.

Multiple dietary techniques indicate little use of commercial fisheries species by gray seals (Halichoerus grypus atlantica) in U.S. waters.

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The return of gray seals (*Halichoerus grypus atlantica*) to the northeast United States has prompted renewed concerns about their significance as fisheries competitors. However, there is limited understanding of their diet and foraging habits in US waters. While many diet studies continue to use prey identifications from remains in fecal samples, they are often paired with a complementary method, such as stable isotope analysis. An increasing number of studies have used DNA metabarcoding to improve taxonomic resolution and the number of taxa identified in predator diets. We used these three methods in tandem to determine gray seal diet from fecal samples collected at haulouts along Cape Cod, Massachusetts, USA to assess potential dietary overlap with commercial fisheries for targeted species. Fecal samples were collected between January 2016 and March 2017 and represent recent foraging activity in inshore waters. The fecal soft matrix was used for both DNA metabarcoding and stable isotope analysis of carbon and nitrogen. The remainder of each sample was analyzed for prey remains. A stable isotope mixing model was used to estimate the proportion of sand lance (*Ammodytes* spp.), squids and benthic fishes to gray seal diet. All three methods revealed that fishes were the main source of food for gray seals, with sand lance and flatfishes as the predominant prey types. Genetic analyses improved taxonomic resolution and doubled the number of taxa identified in seal diet. When these data were compared to a previous investigation of gray seal diet, species richness and diversity decreased over a ten-year period. Overlap between prey items consumed by seals and with commercial fisheries species was low and tended to occur infrequently. These results indicate that gray seals have a less diverse diet than the previous investigations and a reliance on non-commercial species in U.S. waters.

Construction and validation of a dolphin habitat measurement instrument (Tursiops truncatus) in the Port of Veracruz.

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Opinion surveys are used for data collection in social sciences, and one of the areas where such tools are often required is biology research. The aim of this study was to create a social assessment instrument to explore the opinions of the residents of the Port of Veracruz with regard to a dolphin species (Tursiops truncatus) present in the Veracruz Reef System and its habitat. This species is considered a natural indicator of environmental health in the areas where it is distributed. The questionnaire was designed to include 13 Likert-type social impact questions, grouped into two sections: the first six items focused on general information about the species and the remaining seven assessed the respondents' perception of the danger faced by the species and its habitat. Factor analysis based on data obtained in a pilot study with 80 participants revealed a three-construct structure (knowledge of the habitat, risks for the species and conservation of the species) with all 13 items showing sufficient factor loadings and a total explained variance of 62.2%. Reliability analysis of the complete 13-item scale showed good internal consistency, with a Cronbach's alpha coefficient of 0.81. In conclusion, the instrument showed satisfactory validity and reliability for social assessment with regard to views of the state of the ecosystem of marine mammals, in this case the dolphin.

Genetic diversity of leopard seal Hydrurga leptonyx at Danco Coast, Antarctic peninsula.

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The Leopard seal, Hydrurga leptonyx, has a wide distribution throughout the Antarctic circumpolar region. They have solitary habits, haul out on pack ice for long period, and individuals tend to congregate in the same area of the ice for reproduction. The leopard seal shows site fidelity to reproductive sites, which may imply restricted gene flow between groups. In order to conduct the first assessment of genetic diversity of leopard seals in waters around Danco Coast, we amplified mitochondrial DNA Control Region (mtDNA-CR, 423 bp) from DNA extracted from 13 blood samples collected in Primavera base during 2011-2012 austral summer. Our results show high haplotype diversity, represented in unique haplotype for each sample, and only haplotype shared between two samples. Network analyses confirm high diversity with some divergent haplotypes, which suggest that individuals sampled belong to one population. Due to ice dynamic as a consequence of climate change, many individuals are shifting their diet habits, showing dietary specializations which may have the potential to promote genetic differentiation in the long-term. Given the lack of leopard seals genetic studies this hypothesis cannot be tested. Research studies using mitochondrial and nuclear markers are needed to assess the genetic

Return of the fin whales: Feeding aggregations of fin whales around the Northern Antarctic Peninsula.

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Fin whales *(Balaenoptera physalus)* were one of the most abundant whale species in the Southern Hemisphere before their exploitation by commercial whaling, which reduced them to 2% of their pre-whaling population size. Their recovery status today is unknown and information on distribution or abundance is lacking. Over the past years, however, opportunistic observations of high numbers of fin whales have been reported from the Northern Antarctic Peninsula area. We targeted this area with dedicated visual surveys (aerial and shipboard) during four research cruises between 2013 and 2019 to investigate the abundance and distribution of fin whales around the Antarctic Peninsula and along the Scotia Arc. Using distance sampling methods and model-based abundance estimation, we identified high densities of up to 0.114 individuals/km^2 (95 % CI 0.053–0.181). We encountered large aggregations of fin whales during all expeditions, numbering to up to 70 animals feeding together. We were able to film these aggregations by means of helicopter and drone supported camera systems, providing high resolution footage of the behavior and interaction of the fin whales. This is the first documentation of feeding aggregations of fin whales in the Southern Ocean. Furthermore, we collected acoustic data on krill distribution and abundance during feeding events, providing insights into predator-prey interactions.

Our results suggest that fin whales have returned to an area which served as a feeding ground prior to the whaling period, and that they regularly aggregate in the area in high numbers. This may serve as a first indication for population recovery. Future research into population structure and migratory origins is needed for the evaluation of

the current population status. Furthermore, our observations provide first indications for cooperative hunting behavior in fin whales when exploiting krill swarms.

Coda type variation over 30 years in Galápagos sperm whale clans.
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Cultural evolution can manifest as changes in vocal repertoires over time. As long-lived, social, and vocal species, cetaceans often display social structures coupled to vocal communication, which makes them good candidates to undergo vocal evolution. A remarkable example is the sperm whale (*Physeter macrocephalus*). Their societies are segregated into clans that are defined by distinct dialects—repertoires of stereotyped patterns of clicks called codas. However, it is unknown whether and how dialects, or codas themselves, change over time. Here, we document within-coda type variation in the dialects of clans seen off the Galápagos Islands over 30 years. We assigned 10,566 codas to clans based on multivariate similarity analyses of inter-click intervals (ICIs) and used contaminated mixture modeling and principal component analysis to classify the most common codas into types. We then used general linear models to assess if the ICIs of specific coda types changed over time. We found that the Regular (1,750 codas, 5 years, 1985-1995), Short (561 codas, 4 years, 1985-2014), and Four-Plus (1,215 codas, 4 years, 1989-2014) clans exhibit within-type variation across years, but the clan with the most temporally restricted data did not (Plus-One; 788 codas, 3 years, 1985-1989). Therefore, the structure of coda types can change over time and codas also exhibit different patterns—and likely rates—of change. Changes to Regular clan codas occurred across all ICIs, while only some ICIs changed in 'irregular' clan (Short and Four-Plus) codas; this trend reflects the maintenance of codas with equal spacing between clicks within the Regular clan and the increased variation in click spacing and patterning among the two irregular clans. We suggest that these temporal changes in vocal communication stem from within-clan cultural drift, but revealing the extent to which other biological or ecological drivers are involved awaits further research.

A global analysis on the energy content of the diet of the harbour porpoise (Phocoena phocoena)
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The harbour porpoise (Phocoena phocoena) is an opportunistic predator to which quantity of prey might be more important than quality. In the North Sea, prey is often small and/or of low energy content (e.g., gobies, whiting). However, harbour porpoises should probably strive to consume prey with higher energy content to maintain energy balance. In this global analysis, diet studies on stomach contents of stranded or bycaught harbor porpoises were analyzed in more detail regarding average energy contents of ingested prey. The calculated average of all these studies resulted in an energy content of 6.1 kJg-1. However, variation in energy contents in different locations was considerable. In Europe, low energy contents were found in the UK (4.9 kJ·g-1), the Netherlands (5.0 kJ·g-1) and Germany (5.0 kJ·g-1), whereas much higher values were found in the Bay of Biscay (6.3 kJg-1), Ireland (6.8 kJ·g-1) and Kattegat/Skagerrak (7.8 kJ·g-1). Studies at the east coast of the USA showed high energy contents in the Gulf of Maine (6.6 kJ·g-1) and in the Bay of Fundy (8.4 kJ·g-1). In contrast, harbour porpoises in the Salish Sea along the west coast of the USA, took mostly lean blackfin sculpin (Malacocottus kincaidi), resulting in an energy content of only 4.2 kJ·g-1. There is a lack of knowledge on the relationship between diet and fitness of harbour porpoises. Therefore, further monitoring studies that relate prey quality to harbour porpoise vital rates, such as calving rates, age at first fecundity and survival would be recommended.

Protecting the critically endangered vaquita porpoise: Update on illegal net removal efforts.
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ABSTRACT

The vaquita porpoise (Phocoena sinus) is the most endangered marine mammal in the world. This cetacean is endemic to the Mexican region of the Upper Gulf of California, and its population estimated to be at less than 22 individuals. Accidental entanglement in illegal gillnets used to capture totoaba bass (Totoaba macdonaldi) fueled by a lucrative illegal trade for their swim bladders, is the leading cause of mortality for vaquitas.

Despite a ban on the use of gillnets placed by the Government of Mexico in 2015 and extensive enforcement efforts, illegal nets continue to exist within the range of the critically endangered Vaquita. Incidental by-catch mortality of other species of biological importance also occurs in the area. This includes several other species of marine mammals and endangered marine fauna.

The removal of entangling gillnets from their habitat is considered one of the most urgent and important tools for the immediate protection of this species of porpoise. Started by Sea Shepherd's Operation Milagro in collaboration with the Mexican Navy in 2015, the net retrieval efforts were expanded under the lead of the Department of the Environment (SEMARNAT) together with WWF-Mexico, Museo de la Ballena and the fisherman's organization PESCA ABC and Cooperativa Islas del Golfo. Since its formal start in 2016 more than 1100 entangling nets have been removed from the Vaquita habitat through these collaborations. Current net removal efforts are focused in the area of the Vaquita Refuge (established in 2005) where the highest density of vaquitas is estimated to occur, based in acoustic detection trends.

Linking use of ship channels by West Indian manatees (Trichechus manatus) to seasonal migration and habitat use

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Most research on marine mammal occurrence in ship channels focuses on large cetaceans in offshore shipping routes, while nearshore research largely addresses small vessel strikes. Marine mammals, such as the West Indian manatee, that reside in or migrate through nearshore areas, have potential to travel through a wide range of channel types, encountering a greater diversity of vessels than previously recognized. Understanding how and when manatees use shipping channels can help evaluate risk associated with channel use, especially as manatees increasingly occupy habitats outside of their traditional Florida range. We tested the extent and conditions of ship channel use by manatees along the north-central Gulf of Mexico (nGOM) coast by combining data from satellite-tagged individuals, opportunistic citizen-sourced sightings, and environmental attributes linked to manatee movements. Manatees used both nearshore ship channels (130 and 300m wide) and open water fairways but used nearshore channels more frequently, consistent with known habitat requirements. Satellite-tagged individuals swam faster and moved more directly in all channel types, indicating use of these channels as migratory and travel corridors. Accordingly, generalized additive models revealed that manatees used channels most often during spring/early summer and fall and at temperatures coincidental with timing of typical, regional entry and exit migration. Manatees also occurred in ship channels when freshwater discharges were lower, likely because timing of peak manatee occurrence in the nGOM coincides with seasonally lower discharge. Expanded shipping activity world-wide is likely to increase interactions between marine mammals and a variety of vessel types, and these effects may be particularly impactful to migratory animals like manatees that use nearshore habitats at the interface of recreational boating and commercial shipping. By predictably linking ship channel use to migration and habitat use, our approach can aid in risk-assessment for vessel collision and other shipping related activities for migratory marine species globally.

Investigating potential gray whale individual foraging specializations within the Pacific Coast Feeding Group

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Although individual niche specialization within populations has been widely documented, populations are typically managed based on the assumption that all individuals are ecologically equivalent. This approach can be problematic when

a single management strategy is not effective at protecting all individuals within a population equally due to distinct ecological patterns. We examine the presence and degree of individual foraging specialization within the Pacific Coast Feeding Group (PCFG) of gray whales feeding near Port Orford, Oregon, USA. The 264 PCFG gray whales already display a hierarchical form of foraging specialization: At a species level they are the only baleen whale to feed benthically; at a population level PCFG whales do not migrate to the Bering Sea with the other 26,000 Eastern North Pacific gray whales; at a sub-group level there is evidence of temporally and spatially restricted resource exploitation (e.g., ghost shrimp foraging in WA, USA). We tracked 96 gray whales in the nearshore habitat using a theodolite (405 hours) during the same 4 week summer period in four consecutive years (2016-2019). Behavioral classification of these tracks revealed that whales spent almost half of their time foraging (47%), while searching (28%) and travelling (15%) were less prominent. Simultaneous to data collection on whale movements, we collected zooplankton prey samples using a research kayak. Community analysis of these zooplankton samples reveal distinct spatial and temporal patterns in prey availability to whales. We link whale movement and prey data in space and time to assess individual foraging specializations of PCFG whales. With the potential resumption of the Makah tribal gray whale hunt and increased anthropogenic coastal use, increased understanding of the PCFG foraging ecology is needed. Our research will inform management decisions of this small, culturally distinct population unit by identifying resources of high importance to individuals and determining differences in their foraging.

Humpback whales in the Mariana archipelago: Local breeding habitat and links to other western north Pacific breeding and feeding grounds.

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Humpback whales (*Megaptera novaeangliae*) that breed in the western North Pacific (WNP) are listed as endangered under the U.S. Endangered Species Act. Previous research in the WNP concluded that the full extent of humpback whale breeding areas is unknown. Small-boat surveys were conducted during February-March 2015-2018 off the island of Saipan in the Mariana Archipelago to collect humpback whale photos for individual identification and biopsy samples for genetic analysis. Fourteen mother-calf pairs and 27 other non-calf whales were encountered, leading to a photo-identification catalog of 43 individuals. Seven non-calves were re-sighted in multiple years, including 4 females associated with calves in one or more years. This site fidelity of reproductive females and the presence of newborn calves and competitive groups indicate that whales are using the area for breeding. Comparisons of the Mariana Archipelago humpback whale photo-identification catalog with other North Pacific humpback whale catalogs resulted in 10 matches to breeding (Japan and Philippines) and 3 matches to feeding (Russia) grounds in the WNP. DNA profiles of biopsy samples from 24 individuals (14 females, 10 males) revealed 7 mitochondrial DNA haplotypes. The mtDNA haplotype frequencies from the Mariana Archipelago showed significant differentiation from the Okinawa, Japan and Philippines breeding grounds and the greatest identity (i.e., least differentiation) with the Ogasawara, Japan, breeding ground and the Commander Islands, Russia, feeding ground. The study area off Saipan represents only a small portion (12%) of the available breeding habitat with depths <200 m (1,283 km^2) within the Mariana

Archipelago. Future surveys should include other shallow-water areas to determine how many whales are using the Mariana Archipelago and to what extent. The Mariana Archipelago should be considered as a breeding area for WNP humpback whales in ongoing research and conservation efforts for this endangered population.

Is risk-taking behaviour among dwarf minke whales learned or innate?

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Inquisitive behaviours towards humans and boats have been observed in many cetacean species. Such behaviours can increase the risk of vessel strike and entanglement, and repeated interactions can result in desensitisation or habituation, which may also have indirect impacts on fitness and survival from less time spent on critical behaviours.

Dwarf minke whales (*Balaenoptera acutorostrata* subsp.) are renowned for their inquisitive behaviour. During austral winter, they regularly approach vessels and swimmers in the Great Barrier Reef, often to within a few metres, and occasionally to less than a metre. Inquisitiveness has been associated with specific life-history stages in some cetacean species, as seen in juvenile humpback whales and bottlenose dolphins. While previous research has identified several factors associated with close approaches by dwarf minke whales, such as group size and previous exposure to the stimuli, the incidence of such behaviours among demographic cohorts remains unknown.

We investigated the prevalence of close approaches by dwarf minke whales between sexes and life-history stages during 41 commercial swim-with encounters from 2017–2018. Preliminary results suggest there is no difference among sexes or size classes for close approaches; however, two individual whales were responsible for 26% of all recorded approaches closer than 3m. Similar findings have been reported for other higher-risk behaviours such as physical contact, and these patterns of occurrence suggest that the short-term desensitisation of some individuals is occurring. Our study also examines the longer-term sightings history of individual whales to assess the potential for repeat exposure over multiple years to influence risk-taking behaviour.

This detailed understanding of how anthropogenic interactions influence the risk-taking behaviour of dwarf minke whales can assist in appropriately mitigating the threats that arise from such interactions. Furthermore, this study contributes insights into the behavioural ecology of a typically elusive oceanic rorqual rarely observed outside of the Great Barrier Reef.

Using dynamic energy budget models to assess the impact of disturbance on life history and population dynamics of medium-sized cetaceans.

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A challenge in conservation is to assess the levels of disturbance that cause significant adverse effects on wildlife populations. To address this, the Population Consequences of Disturbance (PCoD) framework provides a conceptual model that links behavioural and physiological changes in disturbed individuals to the response of the population. We use Dynamic Energy Budget (DEB) modelling to implement the PCoD framework for medium-sized cetaceans, in particular long-finned pilot whales (*Globicephala melas*). In the DEB model, life history unfolds from the balance between energy increasing processes of resource and milk feeding and energy demanding processes of lactation, gestation, metabolism and growth. With this model we assess how varying levels of disturbance affect the life history of female pilot whales, and how the impact of disturbance changes with changes in abundance and seasonal variation of their prey. Calves born to young females are most sensitive to disturbance, because young females have lower capacity to carry energy reserves, while being faced with high demands of lactation. Higher levels of disturbance also affect survival of calves born to older females, as well as degrading female survival and body condition. These results change when density-dependence operates through prey depletion by pilot whale individuals. In the density-dependent case, disturbance leads to a mortality peak among young, lactating females that have produced their first calf. However, the remaining individuals benefit from an increase in prey availability resulting from the abated top-down control. This leads to an earlier onset of reproduction, increased reproductive output later in life, and increased body condition. Although high levels of disturbance will eventually cause population to go extinct, density dependence is able to mask adverse effects of disturbance on female life history. These results call for a better understanding of density-dependent processes and advocate for caution in the management of marine mammal populations.

At-sea responses to acoustic disturbance in diving northern elephant seals: Venous blood temperature and control of perfusion.

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Marine animals face environmental shifts and increased human activities in the ocean, including shipping, recreation, and seismic exploration. Disturbances may alter short-term behavior and long-term life history patterns, however many of the mechanistic details of responses remain unknown. Because the life histories of marine mammals such as seals rely on their diving abilities, physiological specializations to diving will likely define the scope of underwater response to a disturbance stressor. To characterize physiological responses and their role in buffering impacts of disturbances, we measured an integrated set of cardiovascular and activity metrics in translocated northern elephant seals exposed to experimental acoustic disturbances at-sea. Blood temperature within the extradural vein was continuously logged using an indwelling thermistor. When exposed to an experimental noise disturbance on the ascent phase of a deep dive, juvenile elephant seals exhibited an immediate dive inversion, resuming their descent. This response was accompanied by a rapid decline in venous blood temperature, which reached 31°C in the deepest and longest duration dive inversion. Declines in venous blood temperature have been previously associated with extended diving in this species. Therefore, this physiological response to disturbance may reflect either: an indirect outcome of extended dive durations following the dive inversion or; an intensification of the dive response after disturbance. The rapid decline in blood temperature suggests a short-term change in the dive response. Altered perfusion patterns, such as reduction of muscle blood flow or use of arterio-venous shunts in the flippers, would explain rapid blood temperature declines. In particular, reduced perfusion to working muscle could reduce blood temperature, as well as limit muscle oxygen uptake, and may be a key factor in fine-tuning the dive response after a disturbance. Integrated assessments that include muscle oxygenation will be a next step in advancing our mechanistic understanding of perfusion control in disturbed diving.

A spatial bycatch risk assessment for dugongs in northwestern Sri Lanka.

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Marine mammal bycatch, a major threat to sustainable populations, poses a particular challenge in developing countries. Data to document bycatch and the effects of bycatch are often lacking. We have created a spatial and temporal risk bycatch risk assessment (ByRA) toolbox that makes use of existing data and creates a framework for data acquisition that provides local practitioners and scientists the tools they need to evaluate bycatch risk. ByRA calculates areas of bycatch risk based on the presence or absence of management strategies, the intensity of fishing activity by gear type, and an estimate of the spatial likelihood of interaction between fisheries and species. Our objective was to apply the ByRA toolbox to assess the spatial exposure of dugongs to incidental bycatch in the blue swimming crab (*Portunus pelagicus*) fishery in Palk Bay and the Gulf of Mannar in northwestern Sri Lanka. We traveled to Sri Lanka to meet with agency experts and local scientists. In Palk Bay and the Gulf of Mannar, we met with community leaders and traveled to fishing villages, mapping net use and fishing areas. From observations and conversations, we concluded that the exposure of dugongs to the crab nets is low, due to the placement and configuration of the nets. However, shark/ray nets commonly used by villagers, and illegal commercial trawling close to coasts are risky to dugongs, and also have a highly unsustainable bycatch of marine turtles. ByRA outputs show that the risk of bycatch is most directly associated with areas of fishing occurrence. For the dugong, most of this risk is in the Gulf of Mannar, in areas with illegal trawlers and shark/ray nets. As uncertainty is quite high in this analysis, we caution that risk could be generalized and overestimated. There is a critical need for formal surveys in this area.

First evidence of fish in the diet of long-finned pilot whales (Globicephala melas edwardii) In New Zealand waters

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Knowledge of foraging ecology is important to identify overlap – and therefore potential interactions – between cetaceans and commercial fisheries. However, despite the high frequency of long-finned pilot whale (LFPW; *Globicephala melas edwardii*) strandings on the New Zealand coast, their diet remains poorly understood. To assess LFPW diet and how it may relate to commercial fisheries within New Zealand, we (1) examined stomach contents from a mass-stranding event on Farewell Spit in February 2014 (n=39), and (2) compared these to previously reported data from mass-stranding events that occurred in the same location in 2005 (n=10) and 2008 (n=11). Multivariate analyses were applied to determine temporal and sex differences in the number and size of hard part remains recovered from stomachs during post-mortem sampling. Prey items were evident in 87% (n=34) of individuals examined from the 2014 stranding event (20 females and 14 males). Five individuals (1 female and 4 males) were recorded with empty stomachs. Prey primarily comprised cephalopod remains (542 lower and 476 upper beaks), with the lower beaks belonging exclusively to arrow squid *Nototodarus* spp. Fish remains were reported in the stomachs of four males – representing the first report of fish in the stomachs of LFPWs from New Zealand waters. Although no temporal difference was evident, significantly higher numbers of *Nototodarus* beaks were recorded in the stomachs of stranded females compared to males across all years (2005, 2008 and 2014). Differences in diet observed both between sexes and across all stranding events are discussed in the context of international studies of LFPW diet. Furthermore, first evidence of fish in the diet of LFPWs in New Zealand waters is explored along with the apparent importance of commercially fished arrow squid to the diet of LFPWs in this region.

The Greenlandic harbour porpoise – a separate ecotype?

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Understanding the mechanisms that drive the gradual adaptation and divergence of unique genetic and behavioural characteristics is key in marine mammal management and conservation. In this study, we combine genetic and tracking data to examine the genetic affinity, spatial distribution and habitat use, of harbour porpoises (*Phocoena phocoena*) in West Greenland relative to neighbouring porpoise populations in Canada and Iceland.

Eighteen satellite transmitters were deployed on harbour porpoises and tracked for up to 3 years during 2013-2017 off the coast of West Greenland. Additionally, tissue samples from Canadian (n=26), Greenlandic (n=30, partly from the tagged animals) and Icelandic (n=12) porpoises were used for population genomic analysis using a panel of >1000 single nucleotide polymorphisms (SNPs)

For animals with tags transmitting a full year, the tracking data revealed remarkable long-distance oceanic movements during winter combined with strong summer site fidelity, where all animals returned to the tagging area during the August breeding season. Similarly, the genetic data provided high support for the existence of two populations consisting of 1) harbour porpoises from Canada and Iceland, 2) harbour porpoises from West Greenland alone, respectively. Similar to patterns observed in other suggested North Atlantic harbour porpoise ecotypes in e.g. the Black Sea, Iberia and Mauritania, the genetic data suggests that the Greenlandic harbour porpoises split from other populations in the Atlantic through a bottleneck or founding event about 10,000 years ago associated with the Last Glacial Maximum. We hypothesise that the unique genetic and behavioural characteristics of West Greenland porpoises results from adaptations to regional climate and environment, especially the increased extent of seasonal sea ice coverage. Our findings merit a

revision of harbour porpoise management in Greenland, including implementation of hunting quotas.

Advantages of applying Bayesian framework in the analyses of ontogenetic dietary shifts in a coastal delphinid

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Ontogenetic changes in foraging ecology reflect changes in individual life history, including transition from calf, that maximise growth and survival, to adulthood that maximizes reproduction. As early post-natal survivorship and recruitment plays important role in long-term viability of populations, better understanding of early-life foraging ecology helps unravelling the population dynamics, which is especially important for threatened species/populations, such as Indo-Pacific humpback dolphins (*Sousa chinensis*) that face multitude of anthropogenic pressures. Metabolically inert dentine growth layers provide an annual life history record of individual diet, facilitating studies of ontogenetic dietary shifts. Using micro-milling, we extracted high-resolution dentine material from teeth of humpback dolphins and analysed $d^{15}N$ in all extractable dentine layers (n=441) from 38 individuals (14 males, 18 females and 6 of unknown sex) that stranded in the Pearl River Delta (PRD) between 2007 to 2018.

In the traditional approach of investigating ontogenetic shifts, polynomial functions are fitted to the obtained measurements and population-level changes are determined based on changes in the fitting function. By doing so, individual variability nested within a population-level pattern is frequently undermined. In our study, we performed a hierarchical Bayesian modelling with probabilistic programming using PyMC3 package, assessing individual variability in weaning age, with partial pooling of individual change points nested within the population-level pattern and/or within the inherent differences between sexes. Our results show that humpback dolphins in the PRD wean at the age of 2.51 years (mean), with 95% highest posterior density over the age of 2.11 to 2.92 years, with males weaning ~4 months earlier than females. Given the unusually high calf mortality reported in the past 5 years in Hong Kong, a period marked by extensive coastal construction projects across eastern PRD, our results provide new valuable insights directly applicable in assessing the population long-term viability.

Ontogenetic changes in trace element ratios track lifetime freshwater exposure in bottlenose dolphins (Tursiops truncatus).

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Prolonged freshwater exposure can have harmful effects on bottlenose dolphins (*Tursiops truncatus*), ranging from skin lesions and electrolyte abnormalities to organ failure and death. Determining if a dolphin has been exposed to freshwater for prolonged periods of time can be difficult without costly and labor-intensive direct observation. We tested the feasibility of reconstructing long-term freshwater exposure in bottlenose dolphins using trace element ratios in teeth, which are comprised of annual growth layer groups (GLGs) that assimilate elements reflective of environmental conditions throughout life. Teeth were collected from dolphin carcasses that stranded along the Alabama, USA, coastline between 2011 and 2019. These years encompassed a range of precipitation and freshwater discharge in this freshwater-dominated system. Individuals from multiple size- and age-classes were analyzed using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). There were differences in elemental composition between enamel and lifetime GLGs. Ontogenetic shifts were seen in some elemental ratios (Zn:Ca, Ba:Ca, Pb:Ca) between prenatal and postnatal GLGs, including interannual variation (spikes in Ba:Ca) in postnatal GLGs consistent with seasonal freshwater inputs to the system. Zn:Ca and Ba:Ca were tightly coupled in postnatal dentin while Pb:Ca and Ba:Ca showed similar trends throughout development. These data suggest Alabama resident bottlenose dolphins experience interannual variation in environmental conditions, particularly seasonal pulses of low-salinity that are traceable using elemental ratios in teeth. These results support the potential for trace elements in teeth to be used for assessment and historical tracing of habitat variation, including freshwater and associated

contaminant exposure in bottlenose dolphins throughout their lifetime.

Skin disorders in Risso's dolphins off the west coast of the UK; A photographic assessment.
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Risso's dolphins (*Grampus griseus*) are known for their heavily scarred appearance, which is primarily the result of social interactions with conspecifics. Scarification also results from interactions with other species of delphinid, prey species and anthropogenically induced stressors, such as fishing gear and boats. Another reason for extensive scarring on individual dolphins may be as a result of various epidermal diseases and parasites. Skin diseases have been extensively studied in various species of odontocete, however very little is known about the various cutaneous disorders affecting free-ranging Risso's dolphins. Some studies have shown that the presence, epidemiological pattern and severity of skin disorders can reflect the general health of the population being studied and provide more information as to the level of various environmental and anthropogenic stressors.

Images of individual Risso's dolphins' dorsal fins, heads and bodies taken during photo-identification surveys off the west coast of Scotland and Bardsey Island in Wales between 1997 and 2018 are being used to assess the presence and prevalence of skin disorders, including lesions and epidermal diseases. There is evidence of potential fishery related injuries and collisions with vessels. Interestingly, initial analysis has shown there to be a significant number of individuals with strange 'cow teeth' shaped scars, similar to but startingly different from, bites of the cookie cutter shark which has not been reported in UK waters although suitable habitat exists. However, lampreys are present in UK waters and a similarity with their wound pattern cannot be denied although a detailed comparison has yet to be done. We are only aware of a few similar such wounds having been documented elsewhere and are keen to understand more about the prevalence of skin patterns, lesions or wounds which might be symptomatic of disease, predator-prey interactions or human-induced trauma.

Using drones, artificial intelligence and geospatial techniques to revolutionise dugong and seagrass protection globally.
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Dugongs are an effective barometer for seagrass health; monitoring dugongs facilitates the conservation of this 'Vulnerable' species and the protection of their seagrass habitat that supports the livelihoods of many coastal communities in the dugongs' range. Aerial surveys are the most efficacious method for monitoring dugongs, but traditional manned surveys are prohibitively expensive, dangerous, and require significant expertise. Only 4 of the 46 countries in the dugong's range (90% of which are least-developed or developing) have conducted regular surveys. Our collaborative global efforts, led by the UNEP/CMS Dugong MOU, to conserve dugongs and their critical habitat require user-friendly, affordable and scalable conservation tools. Drones are a cheap and safe alternative, but significant expertise are still required to develop robust survey designs, and extract, interpret and analyse data from drone images. We are developing a suite of tools to assist non-experts to conduct drone surveys. These include small-scale survey designs suited to off-the-shelf drones; and image processing software (Dugong Detector) with integrated geospatial software (OceanMapper). Dugong Detector includes manual and automated (machine learning) processing capabilities for (a) recording details about fauna sightings, (b) classifying visibility conditions experienced during the survey (sea state, turbidity and glare), and (c) classifying visible benthic flora (seagrass/algae). OceanMapper plots these data using the drone's telemetry data. The automated extraction of both sighting and environmental data from the images will produce comparable and standardised data globally. We have trained local researchers in Vanuatu and Philippines to use our tools, and will implement ongoing monitoring strategies for four other developing countries over the next four years. Each country has different levels of local expertise, knowledge of dugong status and spatial coverage requirements. We discuss these challenges, the benefits and limitations of our survey tools, and the degree to which we can ultimately make aerial surveys accessible to non-experts.

Automated seal counts using aerial images and machine learning techniques

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During the breeding and moulting seasons, a predictable proportion of grey seals *Halichoerus grypus* and harbour seals *Phoca vitulina* haul out on land in the Wadden Sea. These seasonal aggregations provide excellent opportunities to make accurate population size estimates. Traditionally, hauled out seals are manually counted, either directly during aerial surveys or from images collected during the survey. In this study we provide an alternative approach, using machine learning techniques (i.e. computer vision) to identify and count seals from aerial survey images.

A Convolutional Neural Network (CNN), pretrained on a large benchmark dataset, was trained using manually annotated aerial images of seals. By using a pretrained CNN, the time to train the network was significantly reduced and training could be done on a single GPU. Resulting seal counts from the CNN were cross validated with manual counts.

The method presented in this study dramatically reduces the time required to process aerial images, while also eliminating the potential effect of observer bias. By using the same architecture and parameter values, the method can easily be employed elsewhere. This process is known as transfer learning and requires only a relatively small set of additional annotated training images and little time to (re)train the network for other regions and/or seal species.

Dig this! – acoustics of detection and localization of a buried target by a bottlenose dolphin (Tursiops aduncus)

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In the wild dolphins are known to be able to detect fish buried in sand to at least 25 cm depth through echolocation. To investigate how a dolphin might do that, and what the underlying acoustics might be, we designed an experiment in which a dolphin was trained to detect and locate a hard-foam target buried in a large sand container (1.2m x 1.1m x 0.6m) that had been placed on the bottom of the pool at 3.5m depth. The dolphin was blindfolded with a set of eyecups during the experiment to ensure that only echolocation cues could be used to detect the target. The target was slowly submerged into the sand over the course of 36 sessions. Nine different locations for the target within the confines of the container were trained and tested. The dolphin was required to station vertically above the location of the buried target for three seconds to indicate that she had correctly identified the location. A planar hydrophone array of 16 hydrophones was placed above the open sand box at a distance of about 10 cm to record the signals that the dolphin emitted during the task. Ten seconds of high-frequency data (sampling rate of 500 kS/sec/channel) were recorded during each trial. As the target was placed deeper into the sand the performance of the dolphin dropped from 75 percent (buried half way) to 64 percent (fully buried). The preliminary analysis of the collected acoustics of the ongoing experiment shows what signals the dolphin emitted during the search for the buried target, how long she searched and how she adjusted her echolocation signals to the changing positions and depths of the target. In particular, the dolphin seemed to prefer lower frequency clicks as compared to a previous echolocation experiment.

Secretive sea monsters on the South African coast: Patterns of beaked whale strandings in space and time.

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The beaked whales (Family Ziphiidae) are perhaps the least known taxon of mammals. Studies of their biology are made difficult by their offshore distribution, deep subsurface habitat, apparent rarity and shy behaviour. This is also true for the Southern African Subregion. We used data collected along the South African coast over the past 50 years by various stranding attendance programmes to infer aspects of their spatial and temporal distribution. Over 200 stranding incidences from nine species have been recorded since 1964. Five of these accounted for 90 % of records: *Mesoplodon densirostris*, *M.layardii*, *M.mirus*, *Ziphius cavirostris* and *M.grayi.* The remaing species were rarely recorded: *Hyperoodon planifrons, M.hectori, Berardius arnuxii* and *Indopacetus pacificus*. The spatial distribution was uneven, with half of strandings occurring within 12 % of the coastline. Six stranding hotspots were noted, all close to cities. The greatest number of incidences (15 % of all strandings) were recorded for St. Helena Bay. Inter-annual changes indicate a gradual increase in numbers of strandings to the mid 1980's, with a subsequent decline for all regions. 1984 was exceptional for strandings, primarily due to large numbers of *M.densirostris* found ashore. Strandings of two of the species, *M.densirostris* and *M.layardii*, were strongly seasonal. Biases in term of sex and age class were apparent for some species. While both spatial and temporal results are influenced by an uneven search effort, they may indicate that the various species of beaked whales have different habitat preferences and distributions in the subregion. This study indicates the value of long-term stranding datasets in assessing the biology of little known marine species.

Use of finite mixture models with stable isotopes to identify source habitat of stranded common bottlenose dolphins

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Strandings are valuable indicators of fishery-cetacean interactions, particularly where observer programs are insufficient. When multiple stocks of a species are parapatric, the stock of stranded or bycaught animals may not be apparent. Five stocks of common bottlenose dolphin, two estuarine, two coastal and one offshore, occur in North Carolina, USA. To date, only the offshore morphotype is distinct. The estuarine stocks are small and are subject to fishery interactions that may exceed sustainable levels. Thus, at least being able to differentiate estuarine from coastal stocks is critical. Characteristic patterns of stable isotopes of carbon, nitrogen, and sulfur have the potential to predict the source habitat— estuary, coast, or offshore—of stranded dolphins. Using stable isotope measurements from skin of dolphins, we developed a finite mixture model in a Bayesian framework to classify individuals according to their source habitat. Classification accuracy was evaluated using a training data set (n=141 biopsy samples). Results were applied to additional biopsy samples ("test" subsample) (n=292) and samples from strandings (n=462). For the test subsample, the predicted stock was consistent with likely stock, determined from the location and season of sampling, for all (n=14) offshore, 92% (n=189 of 205) of coastal, and 72% (n=53 of 74) of estuarine dolphins. For strandings (n=471), the predicted stock was consistent with location of stranding (or genetics for the offshore morphotype) for 100% (n=28) of offshore, 90% (n=346 of 386) of coastal, and 56% (n=27 of 48) of estuarine strandings. The largest discrepancies occurred for predicted estuarine dolphins found on or along the coast, which is consistent with known movements of estuarine-resident dolphins into coastal waters. Stable isotopes are a powerful approach in concert with other information for identifying the source habitats of stranded and bycaught dolphins in North Carolina.

Growing pains: How the juvenile period influences adult male social position and reproductive success within multi-level dolphin alliances.

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In many animal societies, fitness is affected by social factors at various organizational levels of adult social networks. However, few studies have examined whether future fitness can be predicted from juvenile sociality. Indeed, in many gregarious mammals, juveniles are understudied, yet investment in social bonds during this critical period of social development may impact adult reproductive success. In Shark Bay, Western Australia, adult male bottlenose dolphins (*Tursiops aduncus*) form multi-level alliances within a fission-fusion society. Allied males work together to herd single estrus females and these alliance relationships are crucial for each male's reproductive success. Although alliance membership does not crystallize until after sexual maturation, these cooperative partnerships start to develop before males become sexually mature. Here, we use 30 years of data to quantify the changing structure of the social networks of 31 male bottlenose dolphins from their juvenile period through to early adulthood. We quantify how early social network centrality, and social investment (as measured with activity budgets) predict a male's future centrality within the alliance network, as well as his reproductive success (as measured via consortship rate, which is highly correlated with paternities). Our results reveal significant inter-individual differences in temporal change in ego network structure, where individual males engineer their social positions as they mature. This suggests that an individual's gregariousness is a significant determinant of allied male social network position and reproductive success. These findings highlight the importance of including immature life history periods in studies of long-lived species to reveal how early social behavior affects future fitness.

Effects of vessels and their sounds on the foraging dives of endangered fish-eating killer whales (Orcinus orca)

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Anthropogenic disturbance can affect recovery of endangered marine mammals especially if disturbance affects fitness-related activities. Prey availability and vessel disturbance are identified risk factors of endangered Southern Resident killer whales (SRKW) as vessels and their sounds can mask signals used for foraging and disrupt foraging behavior with implications for energy acquisition. To investigate vessel effects, we utilized suction cup-attached digital acoustic recording tags (DTAGs) to investigate sound and movement of SRKW and measure received noise levels to correlate with concurrently-collected geo-referenced vessel data. Previous work demonstrates that SRKW prey capture dives are kinematically distinct and detected with high accuracy when validated with whale acoustic data and predation observations. Here, using kinematic signatures of prey capture, we tested the probability of prey capture for all dives to depth of SRKW preferred prey (>/= 30 m) against a number of covariates including echosounder presence/absence, vessel counts, vessel distance, and vessel speed. We additionally tested several received noise level metrics (mean, median, minimum and maximum for four bandwidths in dB rms) as competing covariates. Commercial echosounder (transmitted and reflected) signals were detected 34% of total deployment time, most often occurred at 50 kHz and correlated with high frequency band noise levels. We found no effect of noise level on the probability of prey capture but flow noise limited available sample size. However, the probability of prey capture decreased as median vessel speed increased, which in turn is a significant predictor of received noise levels. We also tested effects of vessel variables and noise levels on several dive parameters. Duration increased and rate of descent decreased significantly during prey capture dives when echosounder signals were received, indicating effects of prolonged effort to capture prey when vessels emitted sonar. These results inform conservation and management efforts to preserve SRKW foraging opportunities and mitigate vessel effects.

Eco-tour boat compliance to NOAA marine mammal viewing guidelines in Naples, Florida.

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Knowledge of compliance to marine mammal viewing guidelines is essential to understand the interactions and potential impacts of tour operations on cetaceans. This is particularly important in areas of thriving ecotourism, as in Naples, Florida, where in March 2019 tourism contributed an estimated $3.69 million to the economy. Our study examined the compliance of Naples eco-tours operating around bottlenose dolphins (*Tursiops truncatus*) to the U.S. NOAA Marine Mammal Viewing Guidelines, and the ways in which captains' perceptions influence this compliance. Compliance was assessed via 16 observations of 8 boat-based eco-tours during March - April 2019. Captains' perceptions of their compliance to the guidelines, as well as their opinions of the guidelines, were obtained through an online questionnaire distributed after the field observations were completed. Of the twelve NOAA viewing guidelines, tour operators violated, on average, five (42%) guidelines, with two companies violating seven (58%) guidelines. All eco-tour companies (100%) violated three of the guidelines: 1) Do not view dolphins from a distance of less than 50 yards; 6) Never pursue or follow marine wildlife; and 7) If approached by a marine mammal, put your vessel's engine in neutral; allow the animal to pass and move slowly away. The guideline with the next highest rate of non-compliance (75%) was 9) Avoid excessive vessel speed or sudden changes in speed or direction, and do not maneuver a vessel in a way that may change the animal's behavior. Within this guideline, 22% of the 64 total dolphin sightings observed involved eco-tour vessels maneuvering with the intent to induce wake riding. Possible factors affecting compliance include tour educational outreach, captain perceptions and awareness of guidelines, and number of years in business.

Creation of an atlas for the assessment of skin disorders in Canary Islands atlantic spotted dolphins (Stenella frontalis)

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An oceanic form of Atlantic Spotted dolphin (*Stenella frontalis*) inhabits the temperate waters off three mid-Atlantic archipelagos of the Macaronesian region (Azores, Madeira and Canary Islands). Despite scarce information about its biology and state of conservation in the area, there is evidence that the species is threatened by anthropogenic factors, especially pollution and fisheries interactions. Skin disorders can be an indicator of free-ranging cetaceans' health status and can be assessed through the analysis of good quality photographic material. We report on the assessment of skin disorders in Atlantic Spotted dolphins in the Canary Islands through photos obtained from standard procedures during boat-based cetacean surveys carried out between September 2004 and October 2014. In first step, a visual atlas was created to facilitate assignment of the observed lesion linking to their probable etiology. Dolphins were stratified into six age classes based on relative size, morphology and coloration (presence and extent of spotting). A total of 17.318 images were recorded from more than 254 sighting events of the species in the archipelago. All images fulfilling the pre-defined quality requirements such as close-up views (flanks, back, tailstock, head and dosal fin), good focus, light, resolution, allowing the identification of dermal disorders with detail were used in the analysis. Skin disorders were divided into: 1) skin lesions of possible infectious origin, 2) abnormalities in coloration and 3) nonlethal traumas of different origins. Atlantic spotted dolphins showed 16 types of dermal disorders, including tattoo skin lesions, coloration anomalies (piebald), natural (shark predation) and anthropogenic traumas (especially related to fishing interactions). The preliminary results constitute a useful tool that facilitates future research and standardization among researchers.

Simulating collision risk between marine mammals and a tidal energy device: How varying ecological and behavioural parameters impacts our conclusions.

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Marine renewable energy (MRE) development has reached the stage where small-scale arrays are being installed. For tidal MRE, the potential for marine mammals and other large marine vertebrates to collide with a device, particularly the moving parts such as rotors, remains a major concern for consenting/permitting and licencing. Efforts to predict the risk have commonly used formulaic modelling, however whilst providing a solid platform for the incorporation of ecological and behavioural data, this approach is unable to incorporate complex parameters such as varying swimming angles of an animal. Here, we further develop a simulation-based 4D collision risk model first demonstrated by Schmitt et al (2017) which showed how the 3D figure-of-eight trajectory of a tidal kite could be simulated in order to assess collision with a seal-shaped object. Building on from this work, we simulate a similar scenario using gaming software but add additional ecological parameters including: angle of animal approach, swim speed and shape. We then demonstrate how outputs can be post-processed to incorporate further behavioural data such as dive profiles. The results from these simulations provide examples of how variation in the input parameters influences collision probabilities and can lead to a reduction in estimated collision risk. This demonstrates the potential for using simulated collision risk models as a foundation, on which empirical data or expert elicitation could be used to provide more informative estimates of collision risk. In developing this framework, where parameters (including device type) can be varied with relative simplicity, simulation-based collision risk models can be adapted on a case-by-case basis and could therefore provide a more tailored estimation of collision risk for each unique development. Consequently, this work and further developments to incorporate fine-scale behaviour data, such as from sonar/tags, could be of interest to consultants, industry, regulators and their statuatory advisors.

"Pacific Scan I" and "Global Scan I", towards a long-term Marine Mammal Spatial Observatory

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"Pacific Scan" and "Global Scan I", launched respectively in June 2018 and February 2019, are two studies based on recent developments in artificial intelligence to automatically detect populations of endangered baleen whales in satellite imagery.

While the number of studies using satellite imagery to estimate the number of individuals of different species (polar bears, seals, right whales, etc) is increasing, recent studies typically rely on manual counts, human visual assessment, or limited automation which makes analysis a slow and tedious process. In the context of a rapidly increasing amount of spatial big data and rapid biodiversity loss this becomes a considerable impediment to the progress in knowledge which is necessary for conservation.

This presentation introduces the developments- based on a combination of deep learning, classic computer vision techniques, supercomputing and GPU computing- which allowed for fast review, limited false detections, and for a count of marine mammals which exceeded 900 individuals, both adults and calves, with a focus on Eastern Gray Whales and on the yet unknown migration route of critically endangered Western Gray Whales towards South East Asia.

"Pacific Scan" and "Global Scan I", are the first steps towards a systematic use of satellite imagery to rapidly bridge spatial knowledge gaps (migration routes, breeding grounds, etc) for endangered or data-deficient whale species (e.g. Right Whales, Blue and Fin whales, Omura's whales,...).

Interannual variation and trends in marine mammal sighting rates over 30 years (1987-2016) in the Bay of Fundy, Canada

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The Gulf of Maine (GOM), one of the fastest warming bodies of water in the world, has experienced profound environmental and biological changes over the last decade. As waters warm, marine mammals are predicted to shift their ranges. The objective of this study was to describe observed changes in marine mammal sighting rates in the Bay of Fundy, an important and highly dynamic habitat in the northern GOM and a seasonally important feeding ground for endangered North Atlantic right whales. Our analysis leverages 30 years of vessel-based surveys conducted by the New England Aquarium—with consistent data collection protocols and observation platform across all years. We analyzed annual sighting rates for all marine mammal species observed in August and September from 1987–2016. Our analysis revealed increased sighting rates of humpback whales, minke whales, gray seals, and harbor seals; and decreased sighting rates of right whales. Sighting rates for the planktivorous right whale were negatively correlated with those of the piscivorous minke whale, humpback whale, and gray seal ($p<0.05$). Sighting rates of minke whales, fin whales, and harbor porpoise were all positively correlated with each other ($p<0.05$). Grey and harbor seal sighting rates had the strongest pairwise correlation out of all species tested ($r= 0.67$, $p<0.05$). These changes in sighting rates coincide with warming waters and are likely due to shifting prey resources. Our results provide insights into how marine mammals have responded to rapid climate change and highlight the importance of consistent monitoring efforts. By assessing these trends, we hope to better understand the changes in marine mammal use of the Bay of Fundy in the context of the larger Northwest Atlantic climate narrative, which in turn will help inform long-term resource management and conservation efforts.

Participatory science and directed survey methods: A case study with delphinids in the Maui Nui region of the Hawaiian Islands.

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Given the difficulties and costs often associated with surveying cetaceans, enlisting members of the public to collect data offers a promising alternative approach with proper project design and implementation. Furthermore, comparison of cetacean "participatory science" (aka citizen science) data with data collected during traditional scientific studies helps reveal strengths and weaknesses of a participatory science approach and may also improve the robustness of the results. With a large number of vessel operators on the water throughout the year, including dolphin-oriented tour boats, the Hawaiian Islands offer an ideal study site to employ such a dual-method comparison to enhance understanding of nearshore Hawaiian dolphin distributions relative to bathymetry. This study recruited tour and fishing vessel operators using the shallow Maui Nui basin of the Hawaiian Islands to report delphinid sightings. In addition, researchers conducted standard dolphin surveys within the same region. Water depths at locations where sightings were recorded were compared between methods for commonly-observed delphinid species. The participatory science approach was successful in generating a large sample size of sightings from five different species, and these observations occurred in similar depth ranges as those recorded during standard surveys for all species except spinner dolphins (*Stenella longirostris*) and short-finned pilot whales (*Globicephala macrorynchus*). However, both methods indicate that pilot whales occur in the deepest sectors of the study area, while common bottlenose dolphins (*Tursiops truncatus*), false killer whales (*Pseudorca crassidens*) and spinner dolphins occupy areas of shallower depths. Certain improvements are recommended for the participatory science methodology of this study, including documenting the level of effort expended by volunteers and the geographical extent of their observing effort. Ultimately, however, the findings demonstrate the potential value of participatory science and of using a multimethod approach to infer odontocete distribution trends relative to bathymetry in areas where both methods are feasible.

Predicting whale surface feeding activity due to tidal tnfluences in the Stellwagen Bank national marine sanctuary

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Predicting behaviors and distribution is a crucial aspect of understanding the ecology of species which spend the majority of their time beneath the surface. Stellwagen Bank National Marine Sanctuary (SBNMS), located in Massachusetts

Bay, is a feeding ground for numerous whale species. Understanding when surface feeding behaviors occur can help prevent fishing gear entanglements and ship strikes with whales. However, it is poorly understood how exactly whales locate their mobile prey, and so predicting when they will be at the surface is difficult. There have been few studies on tidal influences on whale feeding behavior, and none have investigated the Massachusetts Bay region. This study investigates if tidal flow influences the surface feeding patterns of baleen whales in the SBNMS. Standardized observations of surface feeding behaviors of *Megaptera novaeangliae, Balaenoptera physalus, Balaenoptera acutorostrata, Balaenoptera borealis,* and *Eubalaena glacialis* were collected from opportunistic sighting platforms via commercial whale watch vessels from March 2014 - November 2015. Tidal data was obtained from the NOAA Tides and Currents database and categorized into flows of ebb, flood, and slack. As there is no specific SBNMS tide station, Provincetown, Massachusetts station was chosen as it is the closest proximity to SBNMS. Values were tested using a chi-square goodness-of-fit test, $\alpha = 0.05$. Results show that feeding observations were not equally distributed among the three tidal flows X^2 (2, N = 1280) = 16.98, $p = 0.0002$. The highest number of feeding observations occurred during ebb tide, followed by slack tide. While this study is exploratory, it shows that tidal flow is one the many factors that can help predict whale surface feeding patterns. Determining patterns of when whales are likely to be at the surface can aid in planning of shipping routes and fishing gear placement, and ultimately help reduce injuries and mortalities.

Aerial drone photography to highlight habitat challenges of critically endangered taiwanese white dolphin

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The Taiwanese white dolphin (*Sousa chinensis taiwanensis*) is Taiwan's only endemic cetacean. The population was listed as CR by the IUCN in August 2008. There are about 65 of the animals remaining, all of which reside along the coast of western Taiwan. According to a paper published in 2013 (Sloonton), a rate of death due to human causes of more than one per seven years will result in extinction.

Taiwan ended nearly forty years of martial law in 1987. With the lifting, the floodgates were opened to massive and irreversible development of the west coast such as coal and gas fired power plants, waste disposal dumps, industrial parks, petrochemical and steel plants and so on. After nearly more than thirty years of this unrelenting development Taiwan's west coast has become seriously polluted and the non human natural environment severely compromised. There is but one way to save the TWD from extinction, and that is to preserve the remaining natural habitat.

This is a video compiled from aerial drone photographed footage taken along the coast of the TWD's confirmed habitat and illustrates the current state of heavy human alteration of the sea and land. We hope this video will increase public awareness and understanding of the challenges posed by development to the survival of this population of severely endangered cetaceans having a small and very limited range. We intend to illustrate that protecting the TWD is tantamount to protecting the ocean, rivers and all the beings that rely on these habitats, as well as demonstrating the benefits that the human animal will derive.

It started with a fisher's tale: Interdisciplinary research on marine mammals, their history, and their threats in the Gulf Of Mottama, Myanmar.

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Very little research has been conducted on Myanmar's coastal marine mammals, though it is probable that they, like marine mammals globally, face serious threats. Dedicated research and conservation projects, and local capacity for both, are desperately needed. At the Point B Myanmar Coastal Conservation Lab, led by young local researchers, we combined interdisciplinary research with stakeholder engagement and capacity-building for research at a never-before studied site: the Gulf of Mottama (GoM), along the central part of Myanmar's coastline. This project began in mid-2018, based on conversations with fishers alerting us to the likely presence of coastal cetaceans in the area. Local Ecological Knowledge

(LEK) interviews and boat-based surveys confirmed the presence Indo-Pacific Finless porpoises (Neophocaena phocaenoides), Irrawaddy dolphins (Orcaella brevirostris), and Indo-Pacific Humpback dolphins (Sousa chinensis). LEK interviews indicate that: there is small-scale fisheries bycatch of these species; bycaught cetaceans are often sold and consumed, for meat and medicinal purposes; their distribution has shifted and abundance declined over time; fishers generally have positive perceptions about cetaceans. This work laid a foundation for our ongoing activities, including research on population abundance and bycatch, engagement with communities through participatory research and outreach, and reporting to government entities as part of the larger, multi-sector Gulf of Mottama Project's work to link research to management. To better understand the broader context of Myanmar's coastal marine mammals, we conducted a systematic social media search for posts about marine mammal sightings and strandings, for the whole coastline. We mapped the posted marine mammal incidents to supplement the limited knowledge of marine mammal distribution and threats in the country. This project is an important example of integrating knowledge from diverse sources – from fishers' tales, to social media, to research conducted by local researchers – to fill major data gaps and guide conservation actions for Myanmar's marine mammals.

Habitat selection of Yangtze finless porpoise in the Yangtze River

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Information on habitat selection of critically endangered Yangtze finless porpoise (YFP) is important for effective conservation, but this information is still poorly understood. Generalized additive models were used to assess the YFP abundance and distribution in relation to environmental factors and boat traffic in the Yangtze River. The relative abundance of YFP was conditionally dependent on low chlorophyll-a concentration, high dissolved oxygen concentration, high pH, high ORP, moderate turbidity, high fish density and low ship density(<2.5 ship/km). YFP selected the locations in the river with greater Ratio (ratio of main channel greatest width to smallest width) than area where YFP were absent. Our results indicated that the most likely reason for YFP to prefer the sections of the river with greater Ratio is the relative lower ship density in these area. Although one third of the length of distribution Range of YFP in Yangtze River were already reserves of YFP, human activities (especially boat traffic) in the reserves are still inevitable. With the economic development of the Yangtze River basin, the boat traffic is increasing rapidly. Thus, YFP abundance may decline further due to impact of increasing boat traffic. Based on our results, to design better preforming conservation measures, ship density was suggested to be controlled below 2.5 ship/km at least in the reserves of YFP.

A dynamic approach to estimate the probability of exposure of marine predators to oil exploration seismic surveys over continental shelf waters.

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The ever-increasing human demand for fossil fuels has resulted in the expansion of oil exploration efforts to waters over the continental shelf. These waters are largely utilized by a complex biological community. Large baleen whales, in particular, utilize continental shelf waters as breeding and calving grounds, foraging grounds, and also as migration corridors. We developed a dynamic approach to estimate the likelihood that individuals from different populations of blue (*Balaenoptera musculus*) and humpbacks whales (*Megaptera novaeangliae*) are exposed to seismic surveys as they move over the continental shelf. Animal tracking data for the different populations were filtered and behaviors (transit and foraging) were inferred from the tracks using Hidden Markov Models. We simulated a range of conditions of exposure by having the source of noise affecting a circular area of different radii (5, 25, 50 and 100

km), moving along a gridded transect of 270 and 2,500 km^2 at a constant speed of 9 km h^{-1}, and starting the simulated surveys every week of the year. We developed a standardized index of impact (0 – low impact to 1 – high impact) determined by the cumulative foraging time that individuals are under exposure weighted by the proportion of individuals exposed to the survey. Our results showed a high variability across study sites and relatively low impact of randomly places seismic surveys (e.g. mean index of impact for 50 km radii was ca. 0.07 for both the small and large surveys), as the habitat utilization patterns of each population are highly variable, but allowed us to identify populations that are particularly susceptible to exposure from seismic surveys over shelf waters, as well as the areas where seismic surveys would have the largest impact on these species.

Assessing the seasonal foraging ecology of bowhead whales (Balaena mysticetus) using baleen thyroid hormone (T3) profiles.

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Stable isotope analysis and satellite-linked dive recorders have indicated bowhead whales forage during the winter period, although the relative importance of winter foraging in their annual energy budget remains poorly understood. With growing concerns over the energetic impacts of climate-change induced shifts in prey distribution, it is becoming increasingly important to understand the foraging ecology of Arctic marine mammals. Thyroid hormone (thyroxine, T4, and triiodothyronine, T3) concentrations decrease in vertebrates experiencing a nutritional deficit, which slows metabolism and allows the organism to conserve energy. The objective of this study is to assess bowhead whale foraging ecology using T3 profiles along baleen plates, in combination with previously measured stable isotope profiles.Baleen plates were collected between 1998-2011 from 9 subsistence hunted bowhead whales across the Eastern Canadian Arctic. The plates were drilled at 2-cm increments from the base, down the entire length of the plate, with each increment representing 1-2 months of growth. T3 was extracted using methanol and measured using enzyme immunoassays. T3 concentrations ranged from 202.77-1212.52 pg/g. Autocorrelation analysis revealed no detectable periodicity for T3 and there was no correlation between T3 concentrations and stable isotope values, which did cycle seasonally. The lack of regular seasonal cycles in T3 concentrations supports year-round feeding, strengthening the hypothesis that bowhead whales do not fast during the winter. Intermittent variation in T3 concentrations could be related to short-term disruptions in feeding, potentially while traveling between foraging locations. Knowledge gained from this study will help to identify critical foraging habitat and better understand where and when caloric requirements are met.

Humpback whale mother and calf diving and vocal behaviour during the breeding season in Madagascar.

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In Humpback whale, the mother-calf pair is the only stable social unit, and as in all mammal species, the social bond between the mother and her calf is very strong. Here, we investigate how this bond translates into their diving profiles, swimming and vocal behaviour. We deployed Acousonde on mothers, on calves and on both individuals during 5 successive breeding seasons in Madagascar (2013-2017). We recorded their diving activities, their accelerometry profiles as well as their vocal interactions (20 single deployments, 8 mother-calf simultaneous deployments). Simultaneous deployments showed a very high degree of synchrony, the mother initiating the dive, the calf following its mother and leaving it to breath at the surface several times during a dive. Accelerometer data showed that the swimming behaviour of calves is not as stable and well controlled than adult females. The vocal repertoire of the mother-calf pair was described and correlated with the diving profile. Such investigation allowed us to determine if these calls are emitted in a particular circumstance (surface or bottom activity, descending or ascending phase of the dive) and thus we can suggest a specific

behavioural context. On the 27 calls of the vocal repertoire we focused on 5 calls likely produced by mothers (100Hz, basses, booms, trills, and wop), and 1 call type (heek sounds) by calves. Heek sounds were produced during surface activities and mostly while descending. Basses and wops were recorded mostly during surface activities, trills during shallow dives while descending, whereas booms and 100Hz sounds were produced during diving and mostly while the ascending diving phase. Thus, these different contexts of vocal production suggest different roles or functions for these different types of social calls.

The Franciscana's phonic lips

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In the nasal complex of toothed whales there is a valve-like structure, the Monkey Lips – Dorsal Bursae complex, which is involved in sound generation. Therefore, these lips were called phonic lips and are characterized by grooves running parallel to the general nasal air stream. These grooves on the anterior nasal passage epithelium are shimmed by the anterior dorsal bursae. This situation was found in delphinids, such as the bottlenose dolphin and the humpback dolphin, in the harbor porpoise and in physeterids. Interestingly, in the Franciscana dolphin, *Pontoporia blainvillei*, the situation is slightly different. As revealed by careful macroscopic examination of 7 heads, the position of the grooves - a series of small wrinkles oriented parallel to the air stream - representing the 'monkey lips' is more medial and slightly more distal than the position of the dorsal bursae, at at the border of the dorsal aperture of the nasofrontal air sacs. This means, the area with these characteristics (the area of the small grooves) usually called 'monkey lips' in delphinids and porpoises has a slightly different topography to the (anterior) dorsal bursa in *P. blainvillei*. Accordingly, the anterior dorsal bursae do not shim the 'monkey lips' in *P. blainvillei*. This means in turn, that the epithelial area shimmed by the anterior dorsal bursae is not characterized by grooves or wrinkles in *P. blainvillei*. Although data on the histological structures are still missing in P. blainvillei our results point to the working hypothesis that the phonic lips and the 'monkey lips' may be not homologous in this species.

Localizing and assigning whistles to individual, free-ranging dolphins using a drifting hydrophone array.

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A key element in animal communication studies is the localization of vocal signals to individuals. This is often difficult to achieve for aquatic animals such as dolphins. Bottlenose dolphins (*Tursiops* spp.) communicate using frequency-modulated tonal whistles. Due to the difficulty of identifying vocalizing individuals when dolphins are not isolated, most knowledge on dolphin whistle use comes from studies with captive dolphins or temporarily restrained wild dolphins. However, the findings of such studies are not fully representative of natural behavior and allow only limited inference regarding wild populations. Previous studies on free-ranging wild dolphins have used towed hydrophone arrays with limited localization possibilities. Fixed hydrophone arrays have been used successfully, but mainly in shallow waters close to shore. Here, we propose the use of a drifting hydrophone array as a novel and accurate method of localizing whistles of free-ranging dolphins in open waters and present preliminary results on its performance. We focus on whistles of Indo-Pacific bottlenose dolphins (*T. aduncus*), a species underrepresented in studies of dolphin vocalizations.The array consisted of three hydrophones, each suspended under a free-drifting buoy and attached to an acoustic recorder within the buoy. The buoys were connected to a GPS that continuously logged their position and the recordings were synchronized acoustically. The source location of recorded whistles was then determined using pairwise differences in whistle arrival time between hydrophones. In conjunction with boat-based behavioral observations, footage from an unmanned aerial vehicle, and photo-identification using a camera equipped with a compass and inclinometer, localized whistles were then assigned to individually identified dolphins. With the ability to localize whistles and assign them to individuals, this methodology will provide us with valuable new insights on the social and behavioral context of whistle use in wild dolphins.

Mating season inferences from annual testosterone cycles in baleen of adult male

bowhead whales (Balaena mysticetus)

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Baleen of mysticete whales accumulates steroid hormones as it grows, such that a single baleen plate can be used to reconstruct the individual's endocrine history over the timespan of baleen growth, 1-2 decades in bowhead whales (*Balaena mysticetus*). We analyzed testosterone and corticosterone (an adrenal stress hormone) in baleen of nine adult males from eastern Canada and Greenland to infer breeding season and frequency, and associated stress. Baleen plates of 184-314 cm length were drilled at 2 cm intervals (each interval representing ~1-2 mo), followed by extraction and assay of immunoreactive testosterone and corticosterone. Testosterone concentrations cycled along baleen of all nine males. Average periods ranged from 21 cm in the smallest whales to 14 cm in the largest whales, consistent with annual bowhead baleen growth rates and differential growth rate associated with age (slower in older individuals). Change in testosterone peak amplitude over time was significantly related to whale body length (a proxy of age), with amplitude increasing with age for smaller individuals and decreasing with age for larger individuals, a pattern suggesting influences of sexual immaturity, maturity (reproductive competition), and possible reproductive senescence. Annual testosterone peaks were strongly correlated with stable nitrogen isotope ($\delta^{15}N$) peaks in summer but with an offset of several months, consistent with elevated testosterone concentrations during spring, the purported breeding season. Corticosterone concentrations cycled synchronously with testosterone in some males, while variation was irregular in others; this pattern is consistent with known bowhead whale breeding behavior, i.e. some males are likely non-competitive while others are at peak competitiveness, such that individuals may incur differing levels of breeding-associated stress. We conclude that male bowhead whales exhibit annual testosterone cycles, and that baleen hormone analysis enables examination of reproductive seasonality, onset of sexual maturity, potential reproductive senescence, and other aspects of reproduction in male mysticetes.

Investigating an ongoing Florida manatee Unusual Mortality Event through gut microbiome metagenomics

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A dramatic reduction of seagrass due to long-term, non-toxic phytoplankton blooms in the Indian River Lagoon preceded a Florida manatee unusual mortality event (UME) in Brevard County, Florida. This UME is ongoing since 2012, and a dietary change due to little or no seagrass availability is a hypothesized contributor. To further investigate the gut microbiota and diet consumed by manatees in the area affected by the UME, a high-throughput metagenomic barcoding approach was implemented. The Illumina MiSeq next-generation platform was used to generate non-overlapping 2x300 bp paired-end DNA barcode sequences to provide comprehensive and rapid indexing of species. A targeted sequencing approach based on the bacteria 16S rRNA genes was employed to PCR amplify loci of available microbial species present in the gut. Manatee fecal material (N=20) from UME-associated animals was compared to 'control' samples (N=10) killed by boat strikes from the same area. The MiSeq runs produced millions of sequences with a minimum Phred score of 20 on trimmed reads. This represents a minimum base call accuracy of approximately 99%, providing high confidence in the quality of DNA submitted. Operational taxonomic units (OTUs), observed richness of species diversity (α-diversity), and differences between control and experimental samples (β-diversity) were assessed to determine differences in bacterial species associated with the control and UME samples. Microbiota from over 500 genera and nearly 1800 bacterial species have been identified in the gut and evidence was found for differences in the bacterial communities between the two experimental groups. Sequencing the gut microbiome can help to identify diagnostic species, such as toxic gut microbiota, and irregular community assemblages signifying a physiological change. This high-throughput approach can add to the tools used to investigate this and future UMEs in manatees.

Examining New Zealand leopard seals: The first resident population outside of Antarctica.
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While leopard seals (*Hydrurga leptonyx;* LS) are mainly distributed throughout the Antarctic and subantarctic regions, some vagrants disperse northwards of the Southern Ocean, and usually comprise juvenile animals in poor body condition. To determine if this was the case for LS in New Zealand (NZ) waters, we established the New Zealand Leopard Seal Database (NZLSD), a species-specific collation of more than 2,700 specimens and sightings recorded between 1200 and 2018.Sightings date back to the 1200's and have increased over time, with peak records during the last century. LS have been reported in all seasons and regions of NZ and are predominantly comprised of adult individuals in good or excellent body condition. Juvenile LS's comprise 34% of NZ records and births have also been documented. Through the use of unique pelage patterns, we have catalogued more than 200 unique individuals. The numbers of LS sighted in NZ per annum have continued to increase over time, with the highest record being 74 in 2018. We have documented multi-year occurrence for multiple individuals, with one female showing residency in NZ waters for seven years. To understand why LS occurrence and residency continues to increase in NZ waters, we examined their diet through observing foraging behaviors and conducting and scat analysis. We processed over 100 LS scat samples and recorded the consumption of a variety prey species that included fishes, birds and other pinnipeds. One leopard seal has shown a proclivity to consume seaweed on a regular basis. Using all the data we have collated, we show that NZ's LS's are indeed resident compared to those vagrant's recorded in other regions abutting the Southern Ocean. Furthermore, considering the framework of the NZ Government's Threat Classification System, we show that LS should be reclassified from its status as 'Vagrant' to 'Resident' in NZ waters.

Variances in contour patterns of dugong chirps suggest individual signature.
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Signature calls of marine mammals are useful cues to maintain group cohesion, favoring information about the sender's identity and location. These calls can be important for mothers and calves of dugongs (*Dugong dugon*) that form close cohesion during their nursing period. A previous study has shown that dugongs chirps were used to advertise the location of the sender in the context of vocal exchange (Ichikawa et al., 2011). Here we predict that identity of the sender is also embedded in the dugong chirps. In this study, vocalization contours of chirps of free ranging dugongs were classified. Frequency components of contours were fed into the X-means clustering method. The X-means clustering determines appropriate number of clusters, or k, of the k-means clustering method based on the Bayesian information criterion. Contours of 84 chirps of free ranging dugongs inhabiting the coastal water around Sibu Island, Johor, Malaysia, were classified using the X-means clustering. The chirps were classified into four different groups. Group A chirps showed up-sweep contour patterns with 33 samples, group Bs were down-sweep chirps with 27 samples, group Cs were up-down sweeps with 23 samples, and group D with only one sample. The samples from Johor were also compared with 64 chirps from anonymous dugongs in Thai waters recorded in 2008, 42 chirps from a 7-year-old captive female dugong in Underwater World Singapore, and 19 chirps from a 25-year-old captive female dugong kept in Toba aquarium. Contours of each of the chirps outside Malaysian waters were different from those recorded in Malaysia. These results support a hypothesis that dugong chirps are unique to individual or local population as suggested in Anderson and Barclay (1995). In general, the signature calls are acquired through vocal learnings by calves from their mothers. Our findings contribute to estimate social structure of wild dugong population.

The evaluation of cetacean strandings on the mediterranean coasts of Turkey between 2009 and 2019
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Although some studies exist about the cetacean strandings on the coasts of Turkey, there are still no

systematic stranding network system for cetaceans in the Turkish Mediterranean. In this study, the cetacean stranding cases that were occurred were assessed according to the parameters such as the number of individuals, species, geographical distribution and the status of case interventions on the Mediterranean coasts of Turkey. The data were obtained based on existing images, reported or validated cases were collected from television and newspaper news, web sites, related dissertations and published articles between 2009 and 2019. 89.5% (N=114) of the stranded individuals belong to dolphins, 9.6% to whales and 0.9% to porpoises. The percentages of the stranded species' individuals are as follows; fin whale (*Balaenoptera physalus*) 0.9%, minke whale *(Balaenoptera acutorostrata)* 0.9%, sperm whale (*Physeter macrocephalus*) 0.9%, beaked whale (Ziphiidae) 0.9%, Cuvier's beaked whale (*Ziphius cavirostris*) 4.4%, *Mesoplodon sp.* 0.9%, bottlenose dolphin (*Tursiops truncatus*) 21.1%, striped dolphin (*Stenella coeruleoalba*) 25.4%, short-beaked common dolphin (*Delphinus delphis*) 8.8%, Risso's dolphin (*Grampus griseus*) 1.8%, harbour porpoise (*Phocoena phocoena*) 0.9% and unidentified specimens 33.3%.

According to the IUCN Red List, the identified individuals' conservation status are as follows; 9.5% DD (Data Deficient), 1.4% LC (Least Concern), 72.9% VU (Vulnerable), 16.2% EN (Endangered). Of the stranding cases occured, 8.8% were alive stranding cases. Necropsies were performed for only 17.5% of the carcasses. While 75% stranded indiviuals' causes of death are unknown, 17% died due to disease (infection, parasite, etc.), deliberate killing, drowning (fishing nets), trauma (internal bleeding) etc., 9% are uncertain. It is thought that the obtained data were below actual figures since there was no functioning stranding network for Turkish Mediterranean coasts. Therefore; a stranding network from where continuous monitoring data to be gathered, and necessary first aid were given to ailing animals should be operational.

Estimation of relationship between density surface of humpback whales and environmental factors in the north Pacific ocean using IWC-POWER data

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A new cetacean research programme in the North Pacific Ocean, the Pacific Ocean Whaling and Ecosystem Research coordinated by the IWC (IWC-POWER), started in 2010. Although the ultimate objective of this programme is to provide information on the status of populations of large whales found in North Pacific Waters, knowing the current levels of population is a crucial element of this goal. Among several species, we targeted the humpback whales, which population size was decreased globally once and has been recovered rapidly.

To understand the population size, design-based methods with a line transect survey have been used. Recently, development of model-based methods using information on environmental factors contributing to inferring the distribution and abundance are one of active areas of research. In addition to possible improvement of precision of abundance estimation, outcomes of the approach can contribute to spatial conservation and management. In this study, to examine the environmental factors influencing on the spatial density distribution of the North Pacific humpback whale, the IWC-POWER sighting data were used. The detection function and effective strip half width were estimated by considering wind speed, survey year and cue as covariates. The spatial density distribution was predicted using the generalized additive model (GAM) with location and environmental variable such as the sea surface temperature (SST).

As a result, although different models were selected by different criteria (AIC and deviance explained), the predicted density distribution and abundance estimates were quite similar, which means the results is robust. It is also suggested that the distribution of humpback whales is explained by SST and the ocean depth. The same approach can be applied to other species in the North Pacific, and the integration of analyses may allow us to investigate habitat preferences with link of environmental variables.

Cetacean vertebral trabecular bone mechanical properties and structure among swimming styles and diving behaviors

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Among cetaceans, interspecific variation in vertebral bone contributes to axial body displacement and skeletal loading during swimming. Previous research on terrestrial mammals has detected links between bone mechanical behavior and architecture, and we expect similar findings in caudal oscillating cetaceans. We quantified trabecular bone mechanical properties (yield strength,

stiffness, and toughness) and structure (bone volume fraction, trabecular thickness, and trabecular number) among cetacean functional groups and regions of the vertebral column. We categorized ten species of cetaceans (Families Delphindae and Kogiidae) into functional groups determined by swimming style (rigid vs. flexible) and diving behavior (shallow vs. deep). We hypothesized that the greatest differences will be observed in shallow-diving species which have rigid torsos, habitually overcome surface drag and wave turbulence, and are associated with enhanced swimming speeds. Vertebrae were dissected from four regions of the vertebral column (thoracic, lumbar, and two caudal) and micro-computed tomography (μCT) scanned at 25-35 μm. Bone volume fraction, trabecular thickness, and trabecular number are being calculated from regions of interest within vertebral bodies. Six mm^3 cubes were then cut from vertebrae and compression tested in three orientations at 2mm/min using an Instron dynamic testing instrument. Stiffness, yield strength, and toughness were calculated from stress-strain curves. We found that rigid-bodied, shallow-diving cetaceans (delphinids) mechanical properties different than those from flexible, deep-diving animals (kogids), while animals with rigid bodies that habitually dive deep (delphinids) were intermediate between the two. These data may indicate that in addition to whole body rigidity, animals that navigate forces at the water's surface have increased skeletal loading during active swimming compared with those that incorporate prolonged glides during deep dives. We seek to understand skeletal mechanics and the bone form-function relationship in fully submerged aquatic mammals, whose bodies are supported by buoyant forces in the water column.

Integrating accelerometer and environmental data into state-space models to investigate harbour seal foraging

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Biologging offers important insights into marine mammal underwater behaviour. Spatial movement data and dive depth profiles can be used to identify animal's behavioural states. However, coastal species such as harbour seals consistently make square-shaped bottom dives, making it difficult to characterise core foraging areas or periods of foraging activity.

This study aimed to 1) combine movement and accelerometer data to improve classification of harbour seal at-sea behaviour and 2) assess how spatio-temporal variation in static and dynamic environmental variables influenced their foraging activity.

We used data from two complete foraging trips from each of five adult harbour seals that were tagged with GPS-GSM tags in the Moray Firth, Scotland in 2017. Shed tags were recovered after the moult, providing archived accelerometer data and fine-scale dive profiles. Hidden Markov Models (HMM) were used to classify behavioural states from GPS data, and dive activity parameters and environmental variables were used as covariates. Dive activity parameters were obtained from the accelerometer data, and a water column stratification index was calculated from the temperature data collected by the tag.

Based on GPS movement data alone, the HMM identified three behavioural states: transit, searching and foraging. Several dive parameters derived from accelerometer data (e.g., angles of descent and ascent, prey capture attempts and cumulative mean dynamic acceleration) where found to be in close correspondence to the behavioural states defined by the HMM. These findings were then incorporated into more complex HMM that included both dive metrics and tag-derived environmental covariates. These results provide new insights into the role of static and dynamic environmental variables in shaping harbour seal foraging patterns. Furthermore, they highlight how vast amounts of accelerometer data can be summarised to facilitate data-transmission and how such fine-scale movement and dive summary data can be integrated into location-based movement models.

A Synopsis of Hawaiian humpback whale movements, including migration routes to foraging destinations, from satellite-monitored tracking between 1995 and 2018.

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Humpback whales wintering in Hawaii were satellite-tagged between 1995 and 2018 to study movements, migration characteristics, and dive behavior (duration, depth, and lunges/dive) for up to 160 d. Whales used the Maui Nui region and Penguin Bank extensively, and moved between islands. Mean residence time in Hawaii from tagging to departure was 12.3 d. Migratory destinations included northern British Columbia/Southeast Alaska (5) and eastern Aleutian Islands (4), two of which continued to Kamchatka Peninsula and one continued to the Gulf of Anadyr. Incomplete migration trajectories reinforce the importance of Aleutian Islands and Bering Sea as possible destinations. Two humpbacks tagged 19 years apart extensively used an area ~160 km south of Unimak Pass, suggesting this as important feeding habitat. The north and west coasts of Haida Gwaii, British Columbia, were also high-use foraging areas. Tagged whale ID photos submitted to Happywhale identified resights from Washington, Oregon, and Vancouver Island. Photographs of two tagged whales near Vancouver Island documented expected tag-wound healing. In 2018, tags summarized 61% of dives. Breeding ground dives were generally <100 m, occasionally reaching 400 m. Migration dives were similar, except whales made longer (>15 min) and deeper (>200 m) dives at night during the first 7-14 d. The purpose of such dives is unclear, but may be related to acoustic orientation or magnetic navigation. One whale foraging near the Aleutians had diel differences in dive duration and depth, while whales near Haida Gwaii did not. This study revealed new and complex migratory linkages to high-latitude feeding areas. Tagging was concentrated around the Maui Nui region, but additional sampling at other islands and during different parts of the reproductive season would help us understand how whales from different feeding areas throughout the North Pacific may vary in their timing and geographic use of the islands.

Cetacean bycatch intensity in Bangladesh southeastern and south central coastal marine water.

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We have been monitoring cetacean bycatch along the southeast coast and south central coast as part of our marine megafauna program in Bangladesh for the last 22 years. Bycatch study includes flagship species viz., sea turtle, all cetaceans, whale sharks. Small to large cetaceans have been recorded along the coast of Cox Bazar, Chittagong, Bhola and Patuakhali coast. Data were collected by offshore marine survey, stranding record, dead washed specimen, live observation, data from offshore fishermen, citizen science and marine megafauna bycatch information. 3151 Artisanal marine fishing boast have so far been investigated during the long 2 decades of years. Habitat diversity included estuary, rivers, coastal channels, intertidal flats, mangrove canals, offshore area etc. The diversity of the cetacean species is the least. The region is a very important trans-boundery habitat with Myanmar marine territory. The recorded species include Indopacific humpback dolphin (Sousa chinensis), Indo-Pacific bottlenose dolphin (Tursiops aduncus), Irrawaddy dolphin (Orcaella brevirostris), Risso's dolphin (Grampus griseus), Spinner dolphin (Stenella longirostris) and Finless porpoise (Neophocaena phocaenoides). The habitat loss mostly happened due to indiscriminate construction of dam for shrimp farming, use of estuarine and marine set bag nets (ESBN and MSBN) as well as fishing gears setting across waterways those entirely blocks cetacean movement especially in Naf river, Moheskhali channel, canals of Sonadia-Moheskhali mangrove. Indo-pacific Humpback and Irrawaddy dolphins have been observed very close to coast at Matarbari, Kutubdia, Haserchar, Sonadia and in several other spots along the Teknaf peninsular coast. Interactions with nearshore fishing activity was observed common along Sonadia west coast, near Reju canal and Naf estuary. Alarming number of dead washed individuals due to bycatch during fishing were recorded every year. Major threats observed; gears across rivers/canals, entanglement in fishing gears in offshore fishing activities, indiscriminate movement of vessel through dolphin habitat.Each of the MSBN has the bycatch record.

Marine mammal biodiversity in Oaxaca analysed through the mitochondrial genetic characterisation of strandings and eDNA.

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Strandings of marine mammals can bring a reliable estimation of the biodiversity of this group in a given region. The state of Oaxaca in the Mexican Pacific ranks first in Mexico in biodiversity of terrestrial taxa but little is known about the marine environment. Paradoxically Oaxaca is one of the poorest regions in Mexico which makes it very difficult to obtain funds for dedicated surveys of marine mammals. The most recent study reveals that there are 21 species contained in 5 families present in the region but it is not known if these are resident or pelagic populations. Through the analysis of mitochondrial genetic sequences we can determine or confirm the species present in the area, along with information of the lineages inhabiting these coasts, their genetic variability and their connectivity to neighbouring populations as well as the tempo of their regional appearance. Environmental DNA (eDNA) is a non-invasive technique ideal for biomonitoring that has become an accurate source of species presence information in a given area, but this information is more reliable if there is a reference library of sequences from the taxa that could be detected. We aim to match and compare the information of species richness and its genetic variability obtained using eDNA from sediments and high-throughput sequencing, to the one obtained by strandings. Partial sequences of the mitochondrial control region and COI gene obtained with Sanger sequencing were analysed for a total of 25 individual strandings and compared to the data obtained from a total of 24 samples of eDNA in several localities along the central coast of Oaxaca. These results will provide a reliable and quick tool for monitoring marine mammals in an area where conventional surveys are difficult to carry out.

Sperm whale foraging behaviour during pulsed and continuous navy sonar exposures

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Anthropogenic noise sources range from intermittent to continuous, with seismic and navy sonar technology developing applications with more continuous transmission schemes. Continuous active sonar (CAS) may be used at a lower source level than traditional pulsed active sonar (PAS), but with potential for greater cumulative exposure over time and increased auditory masking concern. We conducted at-sea experiments to contrast the relative effects of navy PAS vs. CAS on sperm whale behaviour using animal-attached sound and movement-recording tags (n=16 individuals) in Norway. Changes in foraging effort and proxies for foraging success and cost during sonar exposures were assessed while accounting for baseline variation (individual effects, time of day, bathymetry, blackfish [killer whale or pilot whale] presence) in generalised additive mixed models. We found no reduction in time spent foraging during exposures to medium-level PAS (MPAS) transmitted at the same source sound pressure level (SPL) as CAS. In contrast, time spent in a non-foraging active behaviour state increased by a factor of 2.4 and 3.3 during CAS and higher source level PAS (HPAS) (Wald test, $F=9.9\text{-}19.8$, $p<0.003$) at similar received sound exposure levels (SEL; squared pressure integrated over signal duration), providing clear support for received SEL over SPL as the response predictor. The responses were relatively short in duration and less than 8% of the individual-average time budget was affected. On-going analysis of acoustic indicators of prey search (clicking depth, inter-click intervals) and prey capture attempts (buzz click rates, duration) will test for changes in echolocation behaviour that may indicate responses to auditory masking. The importance of exposure context including the potential impact of presence of blackfish is discussed. Our results highlight the benefit of using SEL to account for noise sources with different signal duration and/or duty cycle, and the need to consider masking effects for more continuous sources.

Distribution of Pacific white-sided dolphin and Dall's porpoise in the western coast of

Hokkaido, Japan.
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We compared the environment of distribution area of two small cetaceans, Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and Dall's porpoise (*Phocoenoides dalli*) which are distributed in sympatric area. We used the sighting data conducted in the western coast of Hokkaido, northern Japan, onboard Research Vessel *Hokko maru* in May of 2015-2016, when two species move northward to the Okhotsk Sea. We compared the environmental factors (water depth, slope, sea surface temperature (SST) and distance from shoreline) of each cetacean's position at 4km grid resolution. For estimate of spatial niche overlap, niche similarity index (Schoner's D) was calculated by Software ENM tools. During the whole survey period, 24 and 114 schools of Pacific white-sided dolphins and Dall's porpoises were observed, respectively. Pacific white-sided dolphins were observed in the southwestern coast of Hokkaido with warmer SST (above 10℃), whereas Dall's porpoises were observed in the northwestern coast with colder SST (7.5-12.5℃). Pacific white-sided dolphins were observed closer to land (range = 2-30 km, median = 10km) than Dall's porpoises (range = 1-120 km, median = 55km). Pacific white-sided dolphins are considered to move to north later and prefer warmer area than Dall's porpoises. In addition, Dall's porpoises were not observed in the northern inshore area even when Pacific white-sided dolphins were not distributed. These differences could result in the low spatial niche overlap (D: 0.32). In the previous study conducted in the eastern coast of Hokkaido in fall, when two species finished to move north, lower spatial niche overlap was also observed. It might be caused by the difference in their feeding habit, that is, Dall's porpoise prefer offshore and deeper area because they commonly feed on mesopelagic fish, not to avoid pacific white-sided dolphins spatially.

Growls and downsweeps: Foraging ground vocalisations of blue whales.
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Blue whales are known to use vocalisations for social communication in the breeding grounds. Few studies have reported blue whale vocalisations from foraging grounds, therefore the role of these vocalisations is as yet unknown. In this study, we investigate vocalisations of blue whales in their foraging grounds in Skj*á*lfandi Bay, Iceland. Acoustic and behavioural data loggers were attached to the back of whales using a suction cup. 59 hours of acoustic and behavioural data were obtained, including 1141 deep dives. A deep dive was defined when animals dove more than 10 metres and the dive started from a depth of 1 metre. Maximum, minimum and average dive depths were 131, 18, and 48 metres, respectively. Behavioural data were categorized as foraging, travelling, and resting referring depth and acceleration/compass profiles. Whales emitted two types of sounds: growls and downsweeps. Growls showed broadband frequency structure without any clear frequency peak. Growls were emitted at around 10 metres depth, at the beginning and end phases of foraging dives at random. Blue whales may experience rapid air volume change in their body because double or half of ambient pressure shifting between the surface and the depth at 10 metres. Downsweeps from 100 to 40 Hz were detected during travelling and resting immediately before or after consecutive foraging dives. Previous studies reported similar characteristics of blue whale downsweeps in other areas suggested the function of downsweep sounds is likely related to social interaction. This study suggests that downsweeps may also function as a contact call.

Population status and habitat use of a critically endangered ringed seal population in the Gulf of Finland, the Baltic Sea.

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As Europe's inland sea, the Baltic is subject to intense anthropogenic pressure, and the Gulf of Finland is the most affected by human activity. Since the second half of the 1990s the Eastern Gulf of Finland coast has undergone extensive development including the construction of sea freight terminals which increase shipping traffic and lead to decrease of undisturbed natural habitats. The Gulf is inhabited by a population of Baltic Ringed seals (*Pusa hispida botnica*). The population has decreased from estimated 3000 in 1970ies to some hundreds in modern times and the historic continuous distribution has shrunk to the easternmost parts of the sea area. Initially, the decline in numbers was attributed to environmental pollution and unsustainable seal hunting, but the population collapse occurred after a total ban of hunting was introduced in all coastal countries in 1980. Mass mortality of adult seals occurred in 1991, the cause was not established. We carried out aerial census of ringed seals on spring ice in 2018 which resulted the haul-out population estimate of only 113 seals in the sea area. Nineteen ringed seals have been marked with telemetry tags between 1999 and 2018. The sea use patterns in ice free period show decrease of range over time and confinement of distribution to an island-reef system in the eastern part of the gulf. Ice formations at the northeast coast are used for breeding. None of the marked animals left the Gulf, neither any of ringed seals marked in other sub-populations of the Baltic ringed seals have entered the area. The current core habitats are affected by lack of ice due to climate change, exposed to increasing shipping and other anthropogenic disturbance. We find that the isolated population is critically endangered. Dedicated study of health and reproduction success are urgently needed to detect the factors behind the population collapse. IUCN status of the Baltic subspecies, currently 'Least Concern', needs revision.

The active space of sperm whale codas: Inter-click information for intra-unit communication.
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Sperm whales (*Physeter macrocephalus*) are a cosmopolitan species with a multileveled social system in which stable matrilineal 'units' often associate with other units within a larger vocal clan. Clan members share a distinctive repertoire of 'coda types', which are defined by a specific and consistent temporal spacing of multi-pulsed clicks. Multiple interpretations of the function of coda communication exist in the literature in which researchers have hypothesized that codas communicate membership in socially segregated sympatric clans, while also proposing that codas are primarily used for social cohesion within a unit. Here, we test these hypotheses by combining measures of ambient noise levels and coda click source parameters to estimate the active space of sperm whale communication. If a coda's active space is closer to the acoustic footprint of an individual unit, it is likely that codas are used primarily for communication within a unit, whereas if the active space is much larger than the footprint of a unit, it is likely codas are also used for radiating clan identify across units. We measured source parameters of coda clicks from female sperm whales off the coast of Dominica by acoustically localizing clicks with a five-element 80-meter vertical hydrophone array. We calculated the source levels of 1598 clicks from 444 codas to be 173 ± 10 dB re 1µPa, making these sounds among the loudest communication sounds in toothed whales. However, together with measured ambient noise levels and modelled sound propagation, these source levels lead to a median active space of 3.8 km (IQR 1.7 to 6.9 km), which likely reflects the footprint of a single foraging sperm whale unit. We conclude that while sperm whale codas may contain information about clan affiliation, their active space, measured here for the first time, suggests codas likely mediate social cohesion via intra-unit communication.

Quantifying the response of Blainville's beaked whales to Naval sonar exercises in Hawaii
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Naval use of mid-frequency active (MFA) sonar has been associated with injury and death of multiple species of marine mammals. Deep-diving beaked whales (family Ziphiidae) are particularly susceptible to naval sonar. The US Navy operates multiple training and testing facilities where MFA sonar is used regularly, and where cumulative sublethal impacts of exposure to MFA sonar could have negative effects on beaked whale populations. The goal of this project is to quantify the response of Blainville's beaked whales *(Mesoplodon densirostris)* to sonar on the Pacific Missile Range Facility (PMRF) in Hawaii. One indicator of a behavioral response is reduced foraging activity. In the present study, we use data on Blainville's beaked whale dive starts, which are indicative of foraging activity, collected at 62 bottom-mounted hydrophones before and during six Naval sonar exercises. We fit multiple generalized additive models to dive count data collected before and during each exercise using different combinations of covariates and used the best-fitting model to compare the expected baseline dive counts to dive counts observed during the sonar exercises. We found that the average probability of a dive start decreased by half during general Naval training activity on the range and two thirds when MFA sonar was active as compared to the pre-exercise baseline levels when no Navy ships were present. This suggests that animals are responding to Naval activity other than MFA sonar, potentially because they are habituated to the combination of Naval activity and MFA sonar. To investigate this further, we use information on the intensity of low, mid, and high-frequency sound prior to the onset of MFA sonar to identify the noise components associated with reduced foraging activity. In future, we will expand this analysis to include other US Navy ranges where MFA sonar exercises are conducted.

Bottlenose dolphins (Tursiops truncatus) in the Potomac River and Chesapeake Bay, USA

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In the late 1800s, bottlenose dolphins swam not far from where the Lincoln Memorial now stands in Washington, DC. Were they always there? The ecology of the Chesapeake Bay has been heavily studied, but little is known about one of its top predators, the common bottlenose dolphin. To fill this data gap, the Potomac-Chesapeake Dolphin Project launched a study of bottlenose dolphin behavior and population dynamics in the Potomac River and Chesapeake Bay area in 2015. Between July 2015 and October 2018, over 500 individuals were identified within a 37km sq. area with a resight rate of 26%. The linear increase in the number of unique individuals sighted after coding for quality, suggests that many more unique individuals remain to be identified. Although dolphins have been sighted every month between April to October, the mean number of sightings per km of search effort peaks during June (2), July (3.5), and August (3.6), corresponding to peak water temperatures. Group sizes per sighting range from 1 to 163 (n=115) with a mean of 18 animals ($\pm$27 SD). Most groups were observed traveling (67%, n=112), followed by foraging (19%), socializing (11%), and resting (2%). Socializing behaviors, such as mounting, as well as the number of mother-calf pairs (105), including neonates (31) and young of the year calves (33), suggest that the Chesapeake Bay is an important breeding area. Calves have been observed in infant position across multiple years with the longest dependencies extending beyond three years. Dolphins sighted in the Potomac-Chesapeake have been sighted off New Jersey, Virginia Beach, and North Carolina based on contributions to the Mid-Atlantic Bottlenose Dolphin Catalog. Given these matches and the presence of bioindicators (i.e. *Xenobalanus globicipitis*), the animals sighted in the Potomac-Chesapeake likely belong to the Northern North Carolina Estuarine and the Northern Migratory Stocks.

Decreasing whale entanglements in pot and trap fishing gear in Central California.

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Whale entanglements in fishing gear are the leading cause of mortality for humpback whales and the second for blue whales off the U.S. West Coast. Whale entanglements have increased from <10 in 2002-12 to >70 in 2016, and most

entanglements occur in crab fishing gear. We examined seasonal and spatial co-occurrence between whales and fisheries to identify management strategies to decrease entanglements. We used 25 years (1993-2016) of daily whale counts collected from Southeast Farallon Island, Central California to examine changes in timing of migration of whales to this area. We found that whale sightings have increased over time for both species. Foraging migration (northward migration and arrival to Central California) has been occurring earlier and is associated with El Niño. Breeding migration (southward migration and departure from Central California) showed little to no change. Humpback entanglements were correlated with increased counts and early arrival to Central California which increases whale exposure to pot and trap fishing gear in the spring. We used 10 years (2008-2017) of crab pot and whale count data collected at sea by the Applied California Current Ecosystem Studies (ACCESS) to model crab pot and whale densities in relation to climate, oceanography, and depth. We used these models to estimate co-occurrence by calculating the product of pot and whale densities as a proxy for entanglement risk. Since whale prey is expected to be compressed close to shore in warm water years, we compared averages of May risk between warm (2010, 2013) and cold (2008, 2009, and 2011) years. Warm years showed higher risk that was more concentrated close to shore. Management actions to shorten the fishing season and seasonal fishing closures in high risk areas would help decrease the risk of entanglement in Central California particularly during El Niño years when whales arrive early.

Harbour porpoise (Phocoena phocoena) local hot spots found using citizen science

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Harbour porpoises (*Phocoena phocoena)* live in many Northern Hemisphere temperate coastal waters, especially in the North Sea and the western parts of the Baltic Sea. Large efforts have been made to determine the population numbers and distribution of harbour porpoises. This has been done by large- and small-scale surveys, satellite tagging, and acoustic monitoring. Despite of these efforts, the knowledge about harbour porpoise distribution is rather limited, especially in local areas and for critical periods of their life cycle, such as breeding, nursing their young, and foraging. In this project, we use a newly developed app to obtain detailed information on the distribution of harbour porpoises around the island of Funen, Denmark. The app, available on IPhone, IPad and Android platforms, was distributed via radio programs, web pages and social media, as well as organized meetings with sea-related sports clubs, such as sailors and winter bathers. The app was also distributed to ´common citizens´ by posters. Within three weeks after launch, the app had been downloaded and utilized by more than 400 users actively reporting hundreds of harbour porpoise sightings. After data processing to remove double entries and obviously erroneous sightings, the remaining data were used to identify important harbor porpoise sites around Funen as well as potential calving areas. The data provides insight into the detailed lives of harbour porpoises, which can be used in conservation efforts of this species during the most vulnerable time periods of their life cycle.

Tackling cetacean bycatch on the Indian west coast, using innovation

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Fisheries interactions are widely known to result in bycatch, threatening cetacean populations and their conservation globally. In Indian coastal waters, existing data that identifies this threat is based largely on fishery landings only. Very little is known about the nature of these interactions, their spatial distribution, and the various aspects of fishing practices that might influence interactions causing bycatch. Further, the logistical constraints of surveying vast areas, the diverse fisheries sector, and the lack of effective monitoring and management, impede effective data collection. We used fisher reporting networks, fisher interview surveys (n=46), and a user-friendly mobile phone application as tools to gather cetacean-fisher encounter data on interaction nature, frequency, distribution, bycatch occurrence and species. Preliminary results indicate that 30% of fisheries reported bycatch of small cetaceans in their gear, including Spotted Dolphin (Stenella attenuata), Spinner Dolphin (Stenella longirostris), and Finless Porpoise (Neophocaena phocaenoides). Through fisher community networks, we received verifiable geo-tagged records of cetacean presence not previously reported by systematic surveys in the

region. These included Orcas (Orcinus orca), aggregations of Common Dolphins (Delphinus capensis), and Baleen Whales (Balaenopetra sps.). Future analysis of these data could be used to model the risk of cetacean bycatch across the Western coast of India. Fishers in the network are keen to voluntarily help conserve cetaceans and mitigate the impact of bycatch, owing to their traditional reverence for cetaceans, and potentially to obtain access to sustainability/conservation-oriented seafood markets. Such interest and active involvement must be harnessed, to understand and tackle the issue of cetacean bycatch and address the related conservation gap along the Indian West coast.

The challenges of monitoring small cetaceans in tidally energetic environments

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Great Britain holds great potential for marine renewable energy (MRE) developments to support the reduction in fossil fuel dependency that contributes to climate change. Wales is well positioned for tidal resource utilisation due to its exposure to highly dynamic waters. Tidal energy environments often overlap with sites frequented by small cetaceans but their behaviour at these locations is difficult to monitor. To mitigate the impacts of tidal energy developments, it is important for developers and regulators to understand the main challenges involved in studying target species in order to design an effective monitoring programme for pre- and post-deployment data collection. Here, we examined the challenges of observational and static acoustic monitoring techniques that were used to study the harbour porpoise, the most common and therefore likely cetacean to be affected by MRE developments. We identified logistical, physical and analytical constraints throughout the study and several solutions were explored. Harbour porpoises were visually and acoustically detected at tidal sites and Generalised Additive Models (GAMs) were applied to assess the effects of environmental variables on habitat use. Visual encounters were mainly associated with a tidal race, an area of fast flowing water and surface turbulence influenced by certain tidal states. Although tidally energetic sites are linked with foraging opportunities, it is increasingly difficult to observe small species where sea states above 3 are common, decreasing the chances of observing a surfacing cetacean. To obtain useable, statistically strong data that can relate to wider populations, suitable research techniques should be determined and standardised, incorporating our knowledge on the current issues in the field. We demonstrate that it would be unwise to rely on one method alone and suggest using a multi-methodological approach to study the habitat use of small cetaceans at tidal energy sites.

High use of a risky shallow-water foraging environment by common bottlenose dolphins (Tursiops truncatus) in Namibia – not restricted to resident animals.

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A small population of <100 bottlenose dolphins inhabit the coastal zone (<15 m depth) of central Namibia and regularly forage within a shallow tidal lagoon at Walvis Bay. Here there is a substantial stranding risk, with at least 25% of this population previously live stranded. The lagoon is getting shallower with natural and human induced siltation, while simultaneously increasing in 'value' as a refuge from human activities. This study investigates patterns in the temporal use of the lagoon and whether the assumption of risk is ubiquitous to all individuals or only part of the population. Photographic identification data (Jan 2017 to Dec 2018) were used to compare habitat use between the greater Walvis Bay (69 vessel surveys) and restricted lagoon (44 shore surveys) areas. Occurrence patterns were investigated using autonomous click detectors (CPODs) deployed at two sites - a high use site in the bay (Aphrodite Beach) and within the lagoon mouth (Aug 2017 to Jan 2018). We identified 68 animals of which 44 (65%) regularly used the bay and lagoon, and 24 (35%) were only ever seen in the bay. Of those individuals using the lagoon, 16 were considered resident (seen > 20 times), 6 semi-resident (10-20 times) and 22 were seasonal visitors (< 10 times) within the wider study area. Acoustic detections within the lagoon were more than twice that (mean = 0.34, SD, 2.3; 0.15, SD 1.15 minutes.hr^{-1}) of Aphrodite Beach. A strong diurnal occurrence pattern was detected at Aphrodite Beach but absent within the lagoon, where occurrence was driven by tidal influences, peaking on high and ebbing tides. In conclusion, we found that the majority of individuals within Walvis Bay visit the shallow water lagoon environment where they risk becoming stranded. Understanding how animals

use the lagoon environment is especially important in this rapidly changing ecosystem.

Coastal habitat use of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in Jeju Island, Republic of Korea.

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A residential population of about 120 Indo-Pacific bottlenose dolphins resides throughout the year along the Coast of Jeju Island, Republic of Korea. Jeju is one of the most popular sightseeing spots in Korea and its coastal areas are currently undergoing rapid development. The habitat use of this species is poorly understood and conflicts often arise with respect to coastal development and conservation. We investigated spatiotemporal variations in coastal habitat use of Indo-Pacific bottlenose dolphins around Jeju Island for three years from 2014 to 2016. Sighting frequency, behavior type, and activity budgets were collected by land- and boat-based survey. More than 90 percent of dolphin groups were seen in shallow waters <20 m deep and showed no seasonal variations. Ninety-five percent (K_{95}) of the kernel density estimate was used as a measure of alongshore home range, and 50% of the estimate (K_{50}) was used to reveal two core habitat area (CHA) which were located in the northeast and southwest area of Jeju Island. Around the CHA, dolphin groups showed socializing and resting behavior, while traveling and feeding behavior were observed in an area outside of the CHA. This is the first multiyear study of habitat use that defined the core habitat areas for Indo-Pacific bottlenose Dolphins in Jeju Island. This study provides a concrete evidence that both northeast and southwest area of Jeju Island should be preserved to protect the population.

Startle and avoidance reactions of Cuvier's beaked whales to sudden onset sounds

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The Cuvier's beaked whale (*Ziphius cavirostris*) is a species that has repeatedly been found stranded in association with naval sonar operations. Controlled exposure experiments have found a clear response to sonar sounds played from scaled sources. Yet, experimental approaches have not revealed responses that would ultimately lead to strandings unless a noise source were to follow a whale.

Apart from received level, the sudden onset of sonar sounds has been identified as a potentially aversive feature that could contribute to strong avoidance responses. In all tested mammal species, sounds with rapid onset times elicit a startle reflex (a rapid contraction of flexor muscles) which can lead to a sensitization of avoidance responses with repeated exposure. In this study we tested the reactions of Cuvier's beaked whales at the surface to repeated startle sounds to investigate whether animals show evidence of sensitization to such stimuli.

We exposed three individuals to sequences of bandwidth-limited startle sounds with a 20 dB bandwidth from 3.5 to 9 kHz. We monitored the animals' muscle contractions using 3D accelerometry recorded with DTAGs and analysed their avoidance behavior focusing on swim speed, vocalization behaviour and distance covered after exposures. We found that Cuvier's beaked whales have a clear startle response that is consistent with descriptions for other terrestrial and marine mammals. All whales ceased vocalizing, increased swim speed and left the playback site when hearing startle stimuli with a rms received level between 135 and 160 dB re 1 µPa. In a second exposure bout, one animal showed avoidance to a received level of less than 104 dB re 1 µPa rms, suggesting conditioned sensitization may be taking place. We conclude that rise time is a significant component of a noise stimulus that has the potential to amplify avoidance reactions shown by beaked whales.

Between a rock and a hard place: Vessel traffic and declining ice cause compounding risks to harbor seals in a glacial fjord.

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Cruise tourism has burgeoned in Alaska over the past half-century, with annual visitation recently topping 1 million. Glacial fjords are featured on every cruise to Alaska, with Hubbard Glacier—the largest tidewater glacier in North America—projected to draw 214 ships in 2019, up 40% in two decades. The seasonal peak in vessel traffic in adjoining Disenchantment Bay overlaps with harbor seal pupping, which occurs on floating ice. Long-standing concerns about impacts stimulated research on whether ships threaten glacial-fjord seal populations, whose aggregations are some of the largest in the world. Studies describe the distances at which seals react to ships and flush, the energetic costs of extra time submerged, the frequency of close approaches, and the likelihood of population-wide disturbance. These and other findings prompted NOAA to issue more formal, but still advisory, minimum approach distances and transit corridors to promote seal-ship separation. The aims here were to: 1) compare contemporary vessel behavior with earlier studies to assess changes and compliance with new approach guidelines, and 2) examine disturbance effects on seal distribution using GPS-quality locations of ships and seals. Compared to 2002 (N = 27), we found that vessels during June 2017 (N = 39) increased the area used for transiting by 65%, from 26.4 to 40.6 sq km, with most ships operating outside the recommended corridor. Ships also penetrated deeper into the floating ice pack, approaching the glacier at an average 3.8 km (range 0.7-12.4) compared to 9.6 km (2.1-17.8 km) in 2002; 50% approached closer than the advised 1.5 miles. We believe declining ice cover led to ships operating over larger areas and closer to the glacier, and in turn closer to areas of concentrated seals. We assess possible effects of these shifts by comparing metrics of seal distribution across days with varying ship traffic.

Causes of death of harbour porpoises (Phocoena phocoena) found in Belgium between 1990 and 2017

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Between 1990 and end of 2017, 1391 harbour porpoises (*Phocoena phocoena*) were found dead in Belgium (sea, coast, rivers and harbours). There was a significant rise in strandings since the end of the 1990s (on average 5 porpoises/year in the 1990s, 90/year during the last 10 years). The aim of the study is to present the main lesions and causes of death of porpoises and their evolution between 1990 and 2017. Porpoises were selected for necropsy and sampling (histopathology, toxicology, microbiology) following a standard procedure. Frequent observations in the 433 porpoises investigated included net marks, sub-cutaneous and muscular bruises, emaciation, pulmonary blood vessel and airways parasitism, pneumonia and lung congestion and edema. The origin of mortality was determined for 398 porpoises, the two main causes of death were infectious disease (41%) and bycatch (35%). Infectious disease (mainly pneumonia associated with severe parasite infestation) occurred throughout the year. Bycatch was mainly observed in animals that had washed ashore in March and April. Two other causes of death have recently emerged, firstly severe emaciation, combined with lung edema in the absence of other lesions, was considered as evidence of starvation, and secondly grey seal predation with typical lacerations of skin and blubber. Infection by the bacteria *Brucella ceti*was reported in 8% of the porpoises for which it was investigated. The two main reasons for the increase in porpoise strandings during the last two decades are linked with the local increase in density (associated with the southward shift of the population within the North Sea) and the emergence of new causes of death. Increasing numbers of porpoises lead to increased numbers of stranded animals, with the influence of factors such as the emerging phenomenon of predation by grey seals (with populations increasing), bycatch and starvation to be assessed.

Clarifying the taxonomy of the delphinoid cetaceans: A comprehensive review of all nominal species.

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The taxonomy of several genera of small cetaceans is confused, and often has been for decades or even centuries. Recent taxonomic revisions of some genera (e.g., *Orcaella, Sotalia, Sousa, Lagenorhynchus*) have clarified things, but there

are still other genera that await thorough taxonomic treatments, which are sure to recommend generic recombinations and new or resurrected species (e.g., *Orcinus, Tursiops, Stenella, Platanista*). Among the impediments to such resolution is the challenge of identifying proper nomenclature when taxonomic revisions are made, and when new taxa are proposed. There are 353 nominal species of delphinoid cetaceans (most described in the nineteenth century), yet only 50 of these are currently recognized as valid species. Many of the remainder of these names are currently considered to be *nomina dubia* (i.e., of questionable identity), yet information in the literature and examination of the relevant type specimens have often not been adequately pursued. This study is a long-term project, with the objectives of reviewing the status of all nominal species of delphinoids, and documenting their type specimens. Ultimate goals are to identify as many of the *nomina dubia* as possible, and to facilitate the inclusion of data and material (both morphological and molecular) from relevant type specimens into future taxonomic studies.

Adaptations of biosonar behavior to a deep-diving lifestyle in offshore bottlenose dolphins

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Toothed whales are air-breathing, marine predators that depend on echolocation to find prey. Their diverse habitats, ranging from freshwater river systems to extreme depths in the open ocean, pose different challenges to the operation of a biosonar system. Here we test if habitat shapes the biosonar behavior of toothed whales by contrasting the echolocation behavior of coastal and offshore common bottlenose dolphins (*Tursiops truncatus*). Through 2011-2016, we instrumented 68 bottlenose dolphins in Sarasota Bay with acoustic and movement-recording DTAGs during health assessments. We used echolocation clicks from simultaneously tagged mother-calf pairs or bonded males to estimate the difference between tag apparent output and dolphin source level. We found that coastal dolphins produce low-amplitude (SL_{rms}: 186±7 dB re 1µPa), high repetition-rate (median 16 clicks/second) echolocation clicks while foraging in shallow water <10m depth. In August 2016, we instrumented three offshore bottlenose dolphins in Bermuda with DTAGs as part of a larger collaborative investigation into the ecology and physiology of offshore bottlenose dolphins. DTAGs remained attached for up to 23 hours, and all individuals foraged to depths of 400-500m overnight, with dives of up to 1000m recorded on long-term TDR tags. When echolocating near the surface, these animals used source levels of 199±5 dB (~6 clicks/second), but when foraging during deep dives, they increased source levels to 212 ±3 dB (~8 clicks/second), 26 dB higher than typical levels of Sarasota dolphins. These behavioral adaptations increase detection range and therefore search efficiency in an open ocean setting, and thus facilitate efficient exploitation of their deep-water feeding niche. Additionally, peak source levels rival those seen in target detection tasks that investigate the biosonar limits of trained dolphins. This study therefore underscores the flexibility of the bottlenose dolphin biosonar and shows that even within species, habitat is important for determining how animals operate their biosonar.

Environmental influences in the summer and winter movements of satellite monitored fin whales in the Gulf of California

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The movement of the population of fin whales inhabiting the Gulf of California (GoC) was described for the first time through the use of telemetry technology. It seems, that they have seasonal movement from south to north (winter to summer) related to their prey. However, sightings at the beginning of summer at Bahía de La Paz (BLP) and their absence at the end, led to the hypothesis, that their movements are more complex. Here we present new information of their movement from seven Argos satellite tags deployed at BLP (July, 2018) and Puerto Libertad (January, 2019). The behavior mode was related with remote sense data (*SST, Chlo-a*, *POC*, bathymetry) and distance to shoreline. A hierarchical Difference Correlated Random Walk Switching Model was applied to the satellite tag's data to characterize

movement behavior as either "area-restricted searching" (ARS, an indication of foraging) or "transiting" between foraging patches. In both seasons the predominant behavior identified was ARS (77 and 67 %), during which travel speed was slower (1.6±1.09km/h) than during transiting mode 4.07±2.33km/h. The ARS mode was related to shallow waters (-135±147m) and faraway to the coast line in summer and close to it during winter (32-41km). On January fin whales occupied areas with high *POC* (369±137 mg/m^{-3}) and *Chlo-a* (1.5±0.86 mg/m^{-3}) values for feeding activities and they did not move to the south of the GoC. On July two individuals moved to the Midriff Islands. One retuned to BLP. For the first time there is evidence of one fin whale leaving the GoC with ARS mode at the Pacific waters; probably feeding on sardine. Our finding suggests, the part of the population may present spatial segregation related with high productivity areas for feeding (year around) and probably reproductive activities in winter. And a second seasonal movement to the Midriff Islands during summer.

What will it take to protect whales in the Antarctic Peninsula? How innovative science and collaboration can inform Antarctic conservation and policy.

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The Western Antarctic Peninsula is a hotspot of global environmental change manifesting in warmer temperatures and decreased sea ice annually. Commercial krill fishing is concentrated in this area and overlaps with key feeding areas for baleen whales. Tourism is growing with large ships operating in areas that increase the risk of ship strikes and underwater noise pollution. Whales that undertake long migrations from their breeding grounds in tropical waters to the Peninsula navigate additional risks including bycatch in fishing gear and growing pollution.

The Southern Ocean surrounding Antarctica is critical habitat for most of the southern hemisphere's great whale populations. But, with increasing challenges comes opportunity to respond and there is much to be optimistic about. Innovations in whale research including new digital tags, unmanned aerial system technologies, new molecular techniques and access to platform of opportunities are advancing our knowledge allowing us to explore new areas previously impossible to pursue.

Establishing broad, well-managed marine protected areas (MPAs) are a vital part of delivering effective biodiversity conservation. Antarctic ocean life is conserved through coordinated international management by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) which can make binding, consensus decisions and has committed to establishing a network of MPAs surrounding the continent. However, whales are delegated to management under the International Whaling Commission (IWC) and are not considered in CCAMLR's ecosystem-based management decisions related to commercial fishing and long-term monitoring.

We highlight collaboration between research teams from the University of California, Santa Cruz and Duke University with the World Wildlife Fund (WWF) to bring innovative science to public and policymakers identifying critical habitats for MPA design and monitoring and informing better management of the krill fishery. We share a case study highlighting knowledge exchange to achieve policy impact and protect whales for generations to come.

Probability of passive acoustic detection of right whales from autonomous platforms equipped with a near real-time monitoring system

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Mitigation of anthropogenic impacts on North Atlantic right whales and other at-risk species is critical but challenging given the cryptic nature of whale behaviour and the limitations of conventional visual surveys. Using passive acoustic monitoring (PAM) to alert ocean users to whale presence in near real-time can provide an effective mitigation option. The Woods Hole Oceanographic Institution (WHOI) has developed the digital acoustic monitoring (DMON) instrument and low-frequency detection and classification system (LFDCS) to detect and classify baleen whales in

near real-time from autonomous platforms (e.g., buoys and gliders). A limitation of many PAM systems, including the DMON/LFDCS, is the uncertainty in acoustic detection range from the PAM platform. Our goal was to determine the range-dependent probability of detection of the DMON/LFDCS on mobile and fixed platforms. Over a 4-week period in spring of 2017, we concurrently deployed a 4-element vertical line array (VLA), an 8-element horizontal line array (HLA), a DMON/LFDCS-equipped Slocum glider, and a DMON/LFDCS buoy at a shallow (~30m) site ~15 km southwest of Martha's Vineyard, Massachusetts, USA. We used a normal mode back-propagation technique with the HLA/VLA data to localize right whale upcalls, and then conducted a quantitative call-by-call comparison among calls detected on the HLA/VLA and those detected by the glider or buoy using logistic regression to determine the range-dependent detection probability among platforms. The results improve our interpretation of DMON/LFDCS detection data from different platforms, which in turn informs how we use this tool to disseminate more accurate information about whale distribution and near real-time locations to research, government, and industry stakeholders.

Is natural selection shaping Florida manatees? An investigation into the body shapes between the subspecies of the West Indian manatee.

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The West Indian manatee (*Trichechus manatus*) is currently divided into two subspecies: the Antillean (*T. m. manatus)* and Florida manatee (*T. m. latirostris)*. Florida manatees are found at the northern extreme of the species range, primarily inhabiting the waters around the Florida peninsula, while the Antillean manatee inhabits the remaining range from the Caribbean islands to western Brazil. Only in the range of the Florida manatee do waters dip below 20ºC during the winter, and these manatees have to seek warm water refuge for thermal regulation. Allen's rule predicts that in colder climates animals will adapt to have smaller surface area to volume ratios (SA:V). It has been reported that on average, Florida manatees are larger in absolute body size than Antillean manatees. However, no one has explored differences in body shape independent of size between the two subspecies. This study proposes that Florida manatees have stockier body shapes (smaller SA:V) compared to Antillean manatees due to the selective pressure of the colder water. Data on Florida manatee morphometrics (n=834) were obtained from the Florida Fish and Wildlife Commission, while Antillean measurements (n=93) came from live captures in Yucatan and Tabasco, Mexico. SA:V was calculated by creating a geometric model of manatee shape using the standard morphometric measurements. Our study found Florida manatees were significantly longer in length than Antillean manatees ($p=9.91x10^{-3}$). In addition, an ANCOVA on SA:V controlling for total length indicated that the SA:V of Florida manatees was significantly smaller ($p=1.68x10^{-4}$). Therefore, it appears natural selection has not only increased the total body size of Florida manatees, but also altered the body shape in relation to Antillean manatees. Our results lend further support for Allen's rule and indicate that Florida and Antillean manatees are diverging on separate evolutionary paths.

New active and passive sound and movement tags enable long-duration studies of behaviour, ecology and effects of disturbance

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Sound and movement tags (e.g., DTAGs) are powerful tools for exploring the sensory, foraging and social behaviour of cetaceans, and their responses to environmental noise. These tags continuously record wide bandwidth sound along with data from accelerometers, magnetometers and pressure sensors, providing a wide array of behavioural inferences. However, high data rates and associated power consumption typically limit the recording duration to just a few days, constraining the range of behaviours and biological conditions that can be sampled. Here we show that recording durations can be greatly extended by

careful electronics and software design that enhance memory and power efficiency with little trade-off in performance. The resulting DTAG-4 tags have yielded 3-8 week continuous high resolution sound and movement recordings on harbour seals, elephant seals and manatees enabling studies of noise exposure, respiration rates, prey encounters and time/energy allocation. Smaller versions of the tag record for 5 days on penguins and fur seals. An active biomimetic sonar version of the tag with 1-2 month duration collects fine-scale data on the biotic environment experienced by marine animals and predator-prey interactions that have only previously been possible with echolocating toothed whales. With such long recording durations, accurate positioning is needed to georeference behaviours, prey encounters and noise events. To this end the tags contain a tightly-integrated, low-power snapshot GPS which is interpolated by dead-reckoning. Combined with data from AIS logs, the closest approach distance and ship speed can be calculated for each vessel pass, enabling detailed investigations of shipping noise. We offer a roadmap showing the range of species and tasks to which the new long-duration tags are being applied as well as software tools for data analysis. To help identify suitable applications, we also provide a simple methodology to estimate tag lifetime as a function of sampling rate and sensor type.

Automated cetacean identification and measurement using drones and deep learning.

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Photogrammetry has begun to contribute meaningfully to the study of individual and population health, population structure, and understanding changes within marine mammal communities. The flourishing application of drones within marine science provides more opportunity to conduct photogrammetric studies on large and varied populations of many different species. While these new platforms are increasing the size and availability of imagery datasets, established photogrammetry methods require considerable manual input, allowing individual bias in techniques to influence measurements, increasing error and magnifying the time required to apply these techniques. Here we introduce a novel automated image analysis workflow for species identification and morphometric assessment of large marine vertebrates, utilizing a convolutional neural network to demonstrate the potential of a deep learning-based photogrammetry system. We then validate the accuracy of these workflows with traditional approaches to photogrammetry. Our results compare favorably across both techniques. Our automated system correctly predicts whale species with 98% accuracy (57/58) for humpback whales, minke whales, and blue whales. Ninety percent of automated length measurements were within 5% of manual measurements, providing sufficient resolution to inform morphometric studies and establish size classes of whales automatically. In addition to presenting substantial new cetacean body morphology data, this work demonstrates the broad applicability of combining drone-based data collection with neural networks for monitoring of marine animals, highlights the challenges and opportunities in this combination, and is broadly adaptable for future research questions.

Niche partitioning in the largest Antarctic fur seal, Arctocephalus gazella, colony revealed by stable isotopes in whiskers

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Niche partitioning relaxes competition for resources and can enhance the effective carrying capacity of a population. It may play a crucial role in population dynamics of marine predators, which are typically colonial and exhibit central place foraging as breeding locations are limited. We aimed to quantify resource partitioning of Antarctic fur seals breeding at South Georgia, which hosts the highest densities of the species in the world. Antarctic fur seal whiskers, which grow continuously and are not moulted, were collected from 20 males and 20 females at Bird Island, South Georgia. Stable isotope ratios were quantified every 5mm along the length of each whisker. Nitrogen isotope ratios ($\delta^{15}N$) were used as proxies for trophic level, while carbon isotope ratios ($\delta^{13}C$)

were used as broad indicators of foraging habitat. Synchronous oscillations in $\delta^{13}C$ values corresponded to annual migrations and revealed that on average male whiskers grew 1.5 x faster than female whiskers. Spatial segregation was evident between the sexes: $\delta^{13}C$ values were significantly lower in males than females, indicating that males generally spent more time foraging south towards the Antarctic continent. The $\delta^{13}C$ values in females revealed two main foraging strategies: 6 out of 20 females spent most time foraging north of the Polar Front and the remainder to the south of the Polar Front. Female seals that foraged north of the Polar Front had higher $\delta^{15}N$ values and consumed different prey species to those foraging elsewhere. Antarctic fur seals in these age and sex classes face different degrees of inter-specific competition as well as environmental and anthropogenic stressors. This study emphasises the requirements to consider the variability in ecological niches among sex and age groups when formulating plans to conserve species and highlights the importance of niche partitioning in enhancing population carrying capacity.

Re-evaluation of the ocean-basin-wide movement patterns of North Atlantic humpback whales, Megaptera novaeangliae

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The structure of the North Atlantic humpback whale (*Megaptera novaeangliae*) population has not been studied on an ocean-basin scale since the Years of the North Atlantic Humpback (YoNAH) survey of 1992-1993. Despite the lack of updated knowledge, a recent ruling under the United States' Endangered Species Act (ESA) delisted the species globally and split humpbacks in the North Atlantic into two Distinct Population Segments (DPS): the West Indies DPS and Cape Verde Islands (CVI) DPS. The work presented here quantifies the ocean-basin-wide movement patterns of humpbacks over four decades. Our analyses used data from the North Atlantic Humpback Whale Catalog (NAHWC), curated by Allied Whale at College of the Atlantic, for years 1970 – 2015. These data include over 38,000 photographic-identification images of 9,500 whales contributed by over 700 groups and individuals. We estimated transition probabilities between all known mid-to high-latitude feeding areas and breeding/calving areas to elucidate ocean-basin-wide movement patterns and detect differences between breeding regions. Based on emerging trends, our analyses further divided the West Indies into two distinct breeding populations: the Greater Antilles and the southeastern Caribbean. Migratory patterns between feeding areas and the southeastern Caribbean were more similar to those from the CVI breeding segment than the geographically-closer area in the Greater Antilles. Breeding to feeding area transition probabilities were highest from the Greater Antilles to western feeding grounds, from the southeastern Caribbean to eastern feeding grounds, and from CVI to eastern feeding grounds. Thus, the movement patterns of whales breeding in the Greater Antilles are different from those in the southeastern Caribbean, suggesting that whales from these two regions are behaviorally distinct. These findings have implications for DPS delineations under the ESA as well as the international management of whale stocks in the North Atlantic.

Male-female interactions in humpback whales during the breeding season are affected by relative body size and male aggressiveness

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Breeding aggregations of humpback whales (*Megaptera novaeangliae*) are comprised of individuals that vary in sex, reproductive class, age-class, and body size and condition, but how this range of individual physical characteristics and physiological states influences male-female interactions during the breeding season is poorly understood. We investigated how relative body size, age-class and aggressive behavior by lone male humpbacks interrelate and contribute to variability in female time budgets, behavior, and movement patterns. Focal follows with 36 female no-calf groups (male-female pairs) and 29 female-calf groups (escorted mother-calf groups) were conducted on the Hawaiian breeding grounds. Relative fluke size (n=30) and age-class (n=9, sighting histories) was determined for 39 individuals within these groups. Multiple and direct approaches by males to < 1 body length of the female, and chasing, which included multiple approaches, and led to high-speed, energetic chases that persisted over time significantly impacted female behavior. Females with calves (FC) were significantly more likely to be chased by lone males than females without calves (FNC) suggesting that increases in energy expenditure are greatest for lactating females. Overall, 21.4% (22/103) of FC groups were chased compared to 2.2% (2/89) of FNC groups. Chased females swam significantly further distances at increased speeds and spent less time resting than females that were not chased. A significant relationship between fluke size, age and male behavior was also found. Although fluke sizes ranged up to 4.53m in males and 4.61m in females, none of the males that chased females or females that were chased had flukes larger than 4.1m, and none of the males or females of known maturity chased or were chased. Our results suggest that, similar to other mammals, male aggression toward females with calves is commonplace, and raise the possibility that lone, sub-adult males may use this as an alternate mating tactic.

Continuous-time state-space models for marine mammal tracking data: Validation, quality control and behavioural inference.

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State-space models (SSMs) are increasingly relied on to filter error-prone locations from marine mammal telemetry data. In this context, SSMs predict a series of locations using a model to describe animal movements coupled with a model to describe the error-prone observations. Focusing on locations collected via the Argos satellite system, we develop and evaluate continuous-time SSMs that can be easily and rapidly fit to large, multi-individual data sets. The data can comprise CLS Argos' Least-squares- or Kalman filter-derived location estimates, or even a mixture of both. Although several SSM approaches exist to perform quality control of Argos tracking data, few have had their accuracy validated. Using a variety of species' double-tagging data sets, we validate our SSM's predictions against high-resolution GPS data. We then show how SSM's are essential for quality control of ocean observations made via animal-borne telemetry and touch on extensions to our approach for rapid behavioural inference along marine mammal movement paths.

Variations in ecological niche in norwegian killer whales (Orcinus orca) inferred from dietary descriptors and observational evidence

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Killer whales (*Orcinus orca*) in Norway have long been thought to rely on Atlantic herring (*Clupea harengus*) as main food source. However, recent observations in various regions and seasons report additional fish and marine mammal prey species. Prey preferences yet remain poorly understood. We summarize field observations over six years from 2013 to 2018, and dietary descriptors (stable isotope profiles) from skin samples collected in 2017 and 2018 (n=38) of individual killer whales focal-studied throughout the year to draw the first comprehensive evaluation of dietary preferences among killer whales in this region. Of the 1,082

marked identified individuals in northern Norway, 91% (n=988) had wintering herring as seasonal food source. Further, 31% (n=339) were observed in the spring and summer months, after the herring has departed. Identification of prey consumed revealed pinnipeds and lumpfish (*Cyclopterus lumpus*) as alternative prey resources for these whales, with a seasonal diet switch for a minimum of 75 individuals. Low isotope variance and non-overlapping ecological niches confirmed seasonal prey specialization of herring and lumpfish-eating killer whales, reflective of temporary prey abundance. Higher trophic position and wider isotopic niche measured for seal-eating killer whales sampled in all seasons suggested predation on pinniped prey throughout the year, and an inclusion of both fish and mammalian prey to the diet for these groups. Because foraging ecology may influence genetic structuring by shaping social behaviors in killer whales, our results are relevant to assess both the conservation status and role of killer whales in marine ecosystems.

Distribution, site fidelity and habitat utilisation of common bottlenose dolphin in the Gulf of Marseille, southern France (Mediterranean Sea)

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The bottlenose dolphin (*Tursiops truncatus*) has been studied along the French Mediterranean coast since the 90's, but little is known about this species within the Gulf of Marseille. The temporal distribution of dolphins, group dynamics, site fidelity, and habitat utilisation were assessed through mark-recapture photo-identification methodology. A total of 343 hours of boat-based observation, spanning 70 days, were spent at sea between January 2017 and March 2019 in the 2 600 km^2 study area. During this period, dedicated surveys along with opportunistic sightings resulted in 26 groups of bottlenose dolphins being photo-identified. A total of 141 individuals were identified, 35% of which were seen more than once, with sighting frequency ranging from one to twelve. School membership was mixed, typical of fission-fusion societies already described for bottlenose dolphins. 85% of schools were linked by common members. The discovery curve indicates that a large part of the population remains undiscovered. Bottlenose dolphins were observed throughout the year, although seasonality was apparent with more encounters during spring and summer. Photo-identification highlighted that 13 individuals used the Gulf of Marseille on a regular basis, while others were present less often. Thirty-nine dolphins were previously identified in the sector and 4 catalogued dolphins were known from surveys at other coastal sites as far as Genova (Italy) or Barcelona (Spain), thus demonstrating large scale movements of some individuals using the Gulf of Marseille. Foraging was the most frequent behaviour observed. One group was observed feeding on white seabream (*Diplodus sargus*). Most groups (70%) included young, while neonate calves were observed in only two groups. Adults accounted for 85% of all individuals photographed, while young and neonate calves represented 13% and 2% respectively. Further perspectives include contribution of this study to a long-term and integrated monitoring of the population along the French Mediterranean coast.

Fine-scale 3-D whale movement: A simulation model to assess the impact of noise exposure to naval exercises in range.

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There are a number of individual-based animal movement models that can be used to estimate the cumulative exposure of individual marine mammals to sound over the duration of a single navy exercise. However, information on whether or not an individual animal experiences disturbance during a particular navy exercise is not sufficient to assess the broader scale consequence of multiple disturbance over the course of a biologically-meaningful period (e.g., 1 year). We have developed a 3-d movement methodology that uses a Metropolis-Hastings sampler whose horizontal movement is informed only by a density surface that reflects habitat preference. The whale density surface informs the acceptance of a proposed "step" in the movement model. When naval sonar disturbance occurs, the probability of a whale response is mediated through a "dose-response" function tailored to the type of sonar. The strength of the response is treated through the magnitude of the "memory" parameter that informs the directional persistence of the whale away from the source of the initial disturbance. The depth dimension of the sampler is informed by D-tag dive

data from resident and migratory whales in the off-shore naval range of southern California (SOCAL). The whale density surfaces were developed specifically for this region and include monthly temporal resolution. We demonstrate the tool for fin whales and Baird's beaked whales using 3-d acoustic model outputs from a naval exercise completed in this region.

Behavioral responses of satellite tracked Blainville's beaked whales (Mesoplodon densirostris) to mid-frequency active sonar.

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The vulnerability of beaked whales (Family: Ziphiidae) to intense sound exposure has led to considerable interest in their behavioral responses to mid-frequency active sonar (MFAS, 3–8 kHz). Here we present satellite-transmitting tag movement and dive behavior records from Blainville's beaked whales (*Mesoplodon densirostris*) tagged in advance of naval sonar exercises at the Atlantic Undersea Test and Evaluation Center (AUTEC) in the Bahamas. This represents one of the largest samples of beaked whales individually tracked during intensive sonar operations (n = 7). The majority of individuals (5 of 7) were displaced between 28 km and 68 km from their initial locations at the onset of MFAS exposure and generally moved away from the core area of sonar activity in a north-northwest direction. Of the individuals that were initially located on or near AUTEC range all individuals returned within 2-4 d after the end of the exercises. Modeled sound pressure received levels were available during the tracking of four individuals and three of those individuals showed declines from initial maxima of 145-172 dB re 1 µPa to maxima of 70-150 dB re 1 µPa following displacements. Dive behavior data from tags showed a continuation of deep diving activity consistent with foraging during MFAS exposure periods, but also suggested reductions in time spent on deep dives during initial exposure periods. These data provide new insights into behavioral responses to MFAS and have important implications for the modeling of population consequences of disturbance.

Marine megafauna distribution and threats along the offshore Islands of Trat Province, Thailand.

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Marine megafauna distribution around the offshore Islands of Trat Province, eastern Thailand, was investigated via systematic aerial surveys on 28 January–3 February 2018 (7 flight days). This is the first time that aerial survey methods have been employed in this area. Since 2013, boat-based surveys conducted around the islands yielded only four sightings in 11 survey days. This survey was conducted using parallel line transects and covered the waters of Ko Chang, Ko Mak and Ko Kud. These islands are tourism destinations. Fifty-two sightings were observed in water depths ranging 12-15 m, and the total area surveyed was 3382.4 km^2. Minimum six marine megafauna species were identified such as Hawksbill turtle, Green turtle, Indo-Pacific bottlenose dolphin, Irrawaddy dolphin, Dugong, and Whale shark. The sighting of sea turtles comprised 13.4% (n=38) of sightings and were mostly in the shallow reef areas, dolphin sightings comprised 10.0% (n=7) of sightings, while dugong sightings comprised 2.1% (n=4) of sightings and were observed around seagrass areas. The Department of Marine and Coastal Resources have been collecting data on stranded marine megafauna from 2014-2018 resulting in a total of 175 carcasses of sea turtle and cetacean. Necropsies and observations indicated causes of deaths were from incidental catch in fishing gears such as hooks, longline hooks and gillnets (6% n=10), sickness (13% n=23), and garbage (1% n=1). Our survey provides valuable information on the relative abundance and density of animals at particular locations but is not adequate to measure trends or further discern habitat preferences. More surveys over a longer duration will assist in filling

those information gaps. However, our survey enables us to discern areas of marine megafauna overlap with that of human activities. Currently, these Islands are being developed rapidly as tourism destinations, so that conservation and management actions may be recommended.

From feast mode to least mode: How lunge filter feeding biomechanics constrain rorqual foraging ecology across scale.

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Large body size is widely recognized to confer many benefits, including reduced transport costs and enhanced diving capacity. Such advantages should allow divers to increase their ability to forage at depth, thereby increasing overall foraging efficiency. Rorqual whales engulf a large mass of prey-laden water at high speed, which in some species is greater than the body mass of the whale itself, and filter it through baleen plates, retaining prey. This lunge feeding mechanism incurs a large energetic cost due to high drag, but provides the animal with extraordinary prey consumption rates. However, as engulfment capacity increases with body length across species (Engulfment $=\text{length}^{3.2} * 10^{0.612}$, $r^2=0.964$), the surface area of the baleen filter does not increase proportionally (Baleen area $=\text{length}^{1.85} * 10^{0.181}$, $r^2=0.827$). Therefore, we hypothesized that these scaling differences would lead to longer filtration time (Filter time α $\text{length}^{1.5}$) for rorquals of larger body size because the baleen surface area must filter a disproportionally large amount. We tested this hypothesis on five rorqual species using 97 cetacean-mounted video and 3D accelerometry tag deployments with corresponding drone photogrammetry. This data provided direct measures of body size, lunge rates, and filtration times for 15 568 lunges using accelerometry and 233 lunges from direct video observations that confirmed our method. Our findings show that filter time increased with body length (Filter time $=\text{length}^{1.8} * 10^{-0.7}$, $r^2 = 0.76$), whereas the number of lunges per dive decreased with size (Number of lunges per dive $=\text{length}^{-0.8} * 10^{1.7}$, $r^2=0.55$). Although larger rorqual whales should have increased diving capacity, the disproportional cost and filter time required to engulf larger volumes progressively limits dive time that could otherwise be spent selecting the highest quality prey patches. Because larger rorquals commit more resources into relatively larger gulps, they are reliant on dense prey patches to meet their increasing energetic demands.

The plight of Galápagos sea lions: Population decline and future prospects of a colony in the centre of the archipelago.

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Predicting population trajectories based on age-specific vital rates can increase our understanding of relevant population processes, crucial in a conservation context. The Galápagos sea lion population on Caamaño has been monitored since 2003 and declined over the last years. Future population trajectories were predicted by using deterministic and stochastic matrix models based on observed variation in vital rates of two different time periods, an early one where adult female survival rates were still close to 0.95 (2003-2008) and one where all years between 2003 and 2015 were considered and adult survival was 0.83. An elasticity analysis was conducted to determine which vital rates are most critical for recovery. In the deterministic models, the population growth rate (λ) over the next 50 years was predicted to be positive, based on vital rates of the early time period (λ=1.028), but negative based on those of the total time period (λ=0.897). Prognoses worsened when environmental stochasticity,

represented by recent years' sea surface temperature anomalies, was included (λ2003-2015=0.840, λ2003-2008=0.963), and even more when the increase of 0.9°C in mean SST predicted by the IPCC was considered (λ2003-2015 = 0.829, λ2003-2008=0.950). These results imply that over the next 50 years, the sea lion population is facing a danger of extinction. λ was most influenced by adult survival as shown by elasticity analysis. However, survival rates of all age classes are low in comparison to other pinnipeds, indicating a common factor influencing survival. The reasons behind the negative predicted population trajectories could be a decline in prey abundance either due to an increase of El Niño events, general increase in SST, and/or the collapse in sardine abundance which has happened simultaneous to the Galápagos sea lion population decline since the 1970s. These results strongly suggest that current conservation efforts are not adequate for the Galápagos sea

Determing the preferred swimming styles of leopard seals through skeletal muscle physiology.

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The majority of pinnipeds swim using either hind-flipper or front flipper-propulsion. In all of the pinnipeds we have measured, there was a significantly greater aerobic capacity and oxygen storage in their swimming muscles as compared to their non-swimming muscles. Based on this information we set out to determine the preferred locomotory style of the leopard seal by measuring the physiological profiles of both the longissimus dorsi (the main propulsory muscle for hind-flipper locomotion) and the pectoralis major (the main muscle for front-flipper propulsion). The combined results for male and female leopard seals show no difference between the two muscle groups indicating that leopard swim using both forms of propulsion. However when we separated the data into male and female groups, we found a very interesting result. There was a significant difference in males showing that they preferentially swim with their hind-flippers where as it was the females that use both forms of propulsion. This data in combination with our data on fuel utilization and dive behavior will allow us to establish energetic profiles for both male and female leopard seals and permit us to predict their energetic requirements in a changing climate.

Recycling data: A publicly available, annotated acoustic data set with potential uses for marine mammal research and classifier development

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Barkley Canyon is a productive submarine canyon approximately 60 km southwest of Vancouver Island, Canada. The canyon's nutrient flow is affected by multiple regional currents, and draws aggregations of euphausiids, hake, and herring, as well as various marine mammal species. The Barkley Canyon node of the North-East Pacific Time-series Undersea Networked Experiments (NEPTUNE) observatory, operated by Ocean Networks Canada, is instrumented with a variety of oceanographic instruments including a hydrophone. A subset of acoustic data collected from the 2013-2015 hydrophone deployment on the upper slope of the canyon was manually annotated for marine mammal presence as part of a research project focusing on marine mammal habitat use, and in support of development of a random forest classifier. This data set, which is being made publicly available for further use, includes strong-label annotations of phonations from blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), orcas (*Orcinus orca*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), and other delphinids that could not be identified to species. All regional orca communities are represented within the data set, and phonations are labelled to ecotype level and to pod level when possible. This data set could be further used in a number of ways, including classifier development, investigations into habitat use and seasonality, or combining the acoustic data with data collected from co-located oceanographic instruments to investigate links between marine mammal presence and oceanographic conditions.

"Squeak-Thunks": Sequences of multi-element calls produced by bottlenose dolphins while foraging and socializing off Bimini, The Bahamas.

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Bottlenose dolphins (*Tursiops truncatus*) produce a variety of calls across different behavioral contexts, including low-frequency vocalizations. While descriptions of low frequency calls vary across bottlenose dolphin populations, low-frequency calls in some populations have been described as occurring in sequences and/or in combination with other vocal elements. Low-frequency calls are usually recorded in social or foraging contexts. In this study, we documented occurrences of low-frequency "squeak-thunk" vocalizations and sequences produced by bottlenose dolphins off Bimini, The Bahamas, and described the acoustic parameters and behavioral contexts in which they were produced. Squeak-thunks were defined as a call that contained a squeak, or short, narrowband whistle that overlapped with a thunk, a broadband low-frequency pulse (range: 300 – 4000 Hz); these calls may be biphonal in nature. A squeak-thunk sequence could include several repetitions of squeak-thunks, as well as combinations of additional low-frequency elements such as other thunks, gulps, or wheeze gulps (gulps with multiple harmonics). Bottlenose vocalizations were recorded during 17 encounters across 2010-2018 (~8 hours of recording). Group size ranged from 2 – 15 dolphins. Squeak-thunks were present in 9 of these encounters. We analyzed 99 individual or sequences of vocalizations that included squeak-thunks. We found that the behavioral states during which squeak-thunks were recorded were foraging and/or socializing. Squeak-thunk sequences appear to be similar to bray-type sequences reported by other researchers and may be representative of an excitement or a food-related call. Analysis is ongoing to continue to describe and document occurrences of squeak-thunks near Bimini to better understand their function.

Socio-spatial dynamics of a coastal delphinid in a heavily anthropogenically impacted estuarine seascape

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Indo-Pacific humpback dolphins (*Sousa chinensis*) inhibiting the Pearl River Delta (PRD) region, southeast China, are among the world's most anthropogenically impacted coastal delphinids. Although recognized as high conservation priority, the effectiveness of local/regional conservation strategy remains hampered by insufficient quantitative data from the field. We used 7 years of photo-ID mark-recapture data collected in eastern PRD, between Hong Kong in the East and Zhuhai/Macau in the West, to model the dolphins' habitat-use pattern, their spatial connectivity and social dynamics. Spatially, the dolphins display strong preference to areas with relatively natural coastline, within 1 km off the shore, where intensive man-made constructions and coastline alterations have not yet taken place; their habitat-use pattern is predominantly driven by their foraging needs. Over a long-term, individuals exhibit limited ranging and restricted dispersal (~10 km, only a fraction of the study area) with considerable fidelity to specific key habitats. Movement between core areas, although occurs, remain relatively infrequent. Socially, the dolphins form a complex and highly interconnected society with multiple (4-5) closely interacting social clusters. While the clusters partially overlap spatially, which contributes to maintaining social connectivity, they have notably different core areas corresponding to the key coastal habitats. Within a highly fluid grouping pattern, inter-individual associations are non-random but generally weak, with no significant differentiation between sexes or age classes. The temporal pattern of grouping and individual associations appears to be primarily governed by individual preferences to specific habitats and foraging grounds, rather than individual social bonds. However, the importance of dolphin key habitats and habitat connectivity has not been sufficiently recognized in local/regional coastal management planning and majority of these areas are not protected nor prioritized for future conservation. A major realignment of regional approach to conservation is urgently needed if the "urban dolphins" of the PRD are to escape local extinction.

Effects of anthropogenic sound on harbor porpoises (Phocoena phocoena) and harbor seals (Phoca vitulina): Masking and temporary hearing threshold shifts.

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Anthropogenic underwater noise may interfere with, or 'mask', the acoustic communication signals of marine mammals. Even though noise often fluctuates in amplitude, only masking due to constant-amplitude noise has been studied in harbor seals and harbor porpoises. Consequently, the critical signal-to-noise ratios derived in these studies, when used in environmental impact assessment models, result in overestimation of masking effects of both natural and anthropogenic noise. To assess masking more realistically and obtain information about masking effects of variable-amplitude noise, we tested masking by white noise that was modulated in amplitude at different rates and varying in modulation depth and sound pressure level. The higher the noise modulation rate, the higher the masking, except for masking levels close to the unmasked thresholds. The gaps in the noise levels likely enable detection of the signals.

In addition to masking, anthropogenic noise may induce temporary and even permanent hearing threshold shifts (TTS and PTS) in marine mammals; thus, safety criteria are needed to protect their hearing. In harbor porpoises and harbor seals, susceptibility to TTS has only been tested for small parts of their hearing ranges. We tested TTS susceptibility for those parts for which no TTS information existed (i.e., 0.5 & 16-88.4 kHz for porpoises and 0.125-40 kHz for seals). Our preliminary results show that TTS susceptibility in porpoises is very frequency dependent, but in seals it is less variable except for the low frequencies. Once TTS susceptibility has been quantified for the entire hearing range of these two species, auditory weighting functions may be derived for cetaceans that echolocate at high frequencies and phocid seals.

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Tidal drivers of harbour seal Phoca vitulina fine-scale movement, behaviour, and spatio-temporal distribution

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Quantifying the effects of environmental conditions on the movement and behaviour of apex marine predators is crucial for understanding their ecology and informing conservation management. Recent evidence demonstrates that marine mammals utilise tidally energetic areas for important behaviours, such as foraging, however an understanding of how animals respond to changes in tidal conditions remains limited. This information is of crucial interest biologically to improve our understanding of the strategies used by marine predators to exploit energetically challenging conditions. It is also essential in an applied context, as the marine renewables industry target tidally energetic locations to install energy generating devices, raising concerns about potential impacts with marine mammals, such as collision risk. Between 2001 and 2007, 34 harbour seals *Phoca vitulina* (11 females, 23 males) were captured from three locations (Rømø, Denmark, and Lorenzenplate and Helgoland, Germany) in the Wadden Sea, an area boasting a high tidal range and fast water currents. Seals were instrumented with Global Positioning System (GPS) devices and Time-Depth Recorders (TDRs) to record data on their free-ranging movements and behaviour. Here, using a hidden Markov model (HMM) framework, we model these data against high resolution tidal information provided by the German Hydrographic Institute to investigate the influence of changing tidal conditions on the movement, behaviour, and spatio-temporal distribution of seals. We quantify the probability for seals to transition between behavioural states, given tidal phase, and model how their movement speed and heading varies in response to the strength and direction of tidal currents. This framework enables us to quantify within- and between-individual variation, key to obtaining greater understanding of population-level responses. Our results offer novel insights into how apex marine predators utilise and respond to variations in tidal conditions, providing important information towards improving our general understanding of seal ecology and deriving implications for conservation management.

Deep-diving northern elephant seals forage in temperature features measured in three dimensions by biologgers.

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A crucial question in marine ecology, especially in a rapidly changing climate, is the influence of oceanographic processes on foraging success. Associations between marine predators and oceanographic features have been observed across species and systems. These studies have primarily used satellite-derived temperature or altimetry data to identify surface oceanographic features such as fronts and eddies; few utilize subsurface oceanographic data at the scale and resolution of an animal's behavior. Subsurface hydrographic data are especially important when considering deep-diving predators whose prey are further removed from near-surface oceanographic processes. We deployed time-depth recorders or conductivity-temperature-depth data loggers measuring in situ temperature on 154 adult female northern elephant seals (*Mirounga angustirostris*) between 2004 and 2010 to investigate the foraging behavior of a mesopelagic predator relative to temperature features in three dimensions. Horizontal temperature gradients were calculated from tag temperature measurements and foraging behavior distinguished from non-foraging behavior using transit rate and dive profile shape. Temperature gradients from near-surface to 250 m were significantly higher where seals exhibited foraging behavior than where they exhibited transit or drift dive behavior ($p<0.001$). Seals showed increased foraging behavior in primarily submesoscale temperature features (third quantile of horizontal extent of features < 20 km), scales which are challenging to resolve using satellite data. These analyses demonstrate a positive relationship between foraging behavior and variability in water temperature, providing evidence that deep-water prey congregate around such water column features. Recording behavior of a predator utilizing the understudied mesopelagic zone provides valuable insight into the distribution of prey relative to three dimensional oceanographic features, which also sheds light on the spatial foraging ecology of other more cryptic marine mammals, such as beaked whales, that similarly rely on mesopelagic prey.

An acoustic survey of beaked whale and Kogia in the Mariana Archipelago using drifting recorders.

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During the 2018 Mariana Archipelago Cetacean Survey (MACS) a network of 8 drifting hydrophone recorders was deployed on the west side of the Mariana Archipelago with the goal of improving acoustic detection of beaked whales and *Kogia*. These Drifting Acoustic Spar Buoy Recorders (DASBRs) contained a two-element vertical hydrophone array at 150 m depth, sampling at 576 kHz for 2 min of every 5 min. DASBRs generally drifted from east to west between the Mariana Archipelago and the West Mariana Ridge. They collectively sampled from south of Guam north to Pagan along 1,449 km of drifting track during the 19-day sampling period. Periods of clicking were identified using the Click Detector Module within PAMGuard (version 2.00.14c), and each 2-min period was classified based on the spectral and temporal characteristics of the clicks. We found frequency modulated (FM) pulses characteristic of Longman's, Cuvier's, Blainville's, and Cross Seamount beaked whales (BWC), along with narrow-band high frequency clicks from *Kogia.* Collectively, these species were present in more than 500 (3%) 2-min files. The encounter rate was significantly higher for all species on the 5 tracks between Saipan and Pagan than for those drifts occurring farther south. Conductivity-temperature-depth casts conducted during the same period suggest differences in the oceanographic characteristics between the north and south regions that may impact foraging opportunities. Additionally, acoustic detections of beaked whales and *Kogia* on the DASBR tracks were much more numerous than those from the towed array efforts during MACS, highlighting the benefit of using autonomous platforms to augment ship-based surveys. The DASBR data will enhance understanding of the distribution of these species in the Mariana Archipelago and guide future survey efforts in the region.

Ship strike mitigation scenarios within a proposed shipping lane: A pre-emptive decision framework in the remote coastal waters of Pacific Canada.

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As marine shipping routes expand and their traffic rates increase, ship strike is a pressing conservation concern for whale populations throughout a growing percentage of the world's coastal zones. Unfortunately, given that strike modeling studies tend to be focused on established shipping routes in otherwise urbanized waters, ship strike science is often a descriptive exercise rather than a preemptive tool in coastal management. Here we report on three years of visual and acoustic monitoring of whales and vessel traffic within a newly proposed shipping route through remote but culturally, ecologically, and economically important coastal waters in northern British Columbia, Canada. We use these surveys to characterize whale and vessel distribution throughout the year, parameterize vertical habitat use models, and determine current strike risk within the proposed route. Collision models based on current shipping activity are used to estimate the current expected strike rate for fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae).* We then permute these models by escalating traffic rates according to the variety of proposals under consideration by local managers. We examine the effects of various mitigation measures, ranging from minor route alterations to seasonal and diel traffic control, on expected collision rates in each scenario. Our conclusions are framed within a decision framework to which coastal First Nations may refer as they contend with increasing interests in intracoastal shipping within traditional waters.

Implementing the Population Consequences of Disturbance (PCoD) Framework: A case study for marine mammals of the California current.
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The increasing overlap of anthropogenic activities and marine mammal populations is of major concern in conservation and resource management, necessitating the development of decision frameworks and quantitative models to assess the population-level effects of disturbance. The Population Consequences of Disturbance (PCoD) framework is one approach, and requires assessing a population's likelihood of exposure and linking disturbance-induced changes in individual behavior with changes in health, vital rates, and population dynamics. Significant progress has been made applying the PCoD framework to individual species. For this study, however, we apply the PCoD framework to forecast the effects of disturbance for multiple species (or populations/stocks), using a simulated 3D seismic survey offshore southern California as a case study. We begin by using a decision framework (developed under the Office of Naval Research-funded PCoD+ project) to identify and prioritize species for which detailed population-level assessments are needed based on species-specific life history and residency patterns relative to survey activities. We also consider the duration and exposure probability for a given individual and population based on current distribution from sightings and tracking data for available species (e.g., blue, humpback, and Cuvier's beaked whales). Once priority species are identified, we use bioenergetic models to estimate the energetic costs of the seismic survey on female and calf/pup survival, and the resulting impacts on population dynamics. For species with limited data to parameterize the model (e.g., beaked whales), we provide guidance for how to apply existing data based on life history traits. The PCoD framework is a powerful tool to quantify the potential impacts of disturbance on a population, as well as explore the potential consequences of changes in disturbance, including environmental variation, on long-term population dynamics. Ultimately, this information can be used to inform practical risk assessments, as well as effective management and conservation strategies.

An investigation of the cervical gland secretion of the pygmy sperm whale (Kogia breviceps).
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In odontocete cetaceans, chemoreception, including the senses of olfaction and gustation, are considered to be absent or highly reduced. It is also generally accepted that odontocetes lack specialized exocrine glands, which function in terrestrial mammals to produce chemical signals involved in communication. In 2016 and 2018, though, Keenan-Bateman and colleagues described a morphologically complex, cervical exocrine gland, associated with the false gill slit pigmentation pattern, in *Kogia breviceps*. The goal of this study was to provide preliminary chemical analyses of the cervical gland to gain insights into its potential functions through comparisons with known exocrine gland secretions of terrestrial Cetartiodactyla. We used multiple techniques, including seriate histochemical protocols, paired with polarized microscopy, to examine glandular secretory components; and scanning electron microscopy with energy dispersive X-ray spectroscopy (EDAX), and Raman and mass spectrometry, to provide elemental identification and quantitative composition of the secretion. Our results demonstrate a histochemical transition of the secretory epithelium, as cells mature and progress from the basal lamina to the lumen, where they slough off to form a holocrine secretion. Histochemical and EDAX results demonstrate that the secretion is a chemically complex mixture of protein, carbohydrate, and lipid. A highly unusual constituent of the secretion is crystalized uric acid. Crystallization of uric acid within mammalian tissues is usually considered pathologic, but these crystals appear to be an important, natural component of the cervical gland's secretion. Thus, like the specialized exocrine glands of terrestrial mammals, the cervical gland of *K. breviceps* is species-specific (absent in *K. sima*), constrained to a unique anatomic location, and morphologically and chemically complex. While the presence of uric acid is very unusual, together these attributes suggest the cervical gland produces a chemical signal that may be used in communication, although the function of that signal remains unknown and warrants further investigation.

Characterising injuries and pathology of common dolphin (Delphinus delphis) mortalities in the South Australian sardine fishery

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Mortality of dolphins in fishing operations is a concern worldwide yet its magnitude is often under-estimated, as shown by studies of beach-washed carcasses. Linking evidence obtained during necropsies with fishing method is fundamental to understanding the extent of mortality. The South Australian Sardine Fishery (SASF) has operated in inshore waters since 1991, with mortality of common dolphins high prior to 2005. Our study characterised the injuries and pathologies associated with mortality in this purse seine industry. Forty-nine dolphins were collected from SASF (2006–2019). Necropsies were performed, and life history and skeleton fractures later evaluated. Neonates, calves and juveniles accounted for 59% of the sample. Of mature females (n = 14), 11 were pregnant and/or lactating. Body condition was robust 48 dolphins. Externally, bruising was observed in all dolphins. Net and rope marks were seen on 75% of dolphins, mostly on the head, trunk and peduncle. Broken/missing teeth were noted in 65% of dolphins, sometimes associated with superficial cuts. All dolphins had subdermal haemorrhaging (moderate to severe in 96%), particularly around the head. Deep haemorrhaging was common, including on occipital and flipper condyles, and organs. Abundant fluid was present in the thorax and abdominal cavities of half of the dolphins. Fluid and froth were observed in lungs of 98% and 38%, respectively. Acute, unhealed bone fractures were documented in 48% of dolphins, primarily for the skull, ribs and vertebrae, and most were associated with haemorrhaging. Stomachs contained partially digested prey in 61% of dolphins. We conclude that blunt trauma was the primary cause of death. Many dolphins also had mild heart pathology that in preliminary results showed little similarity to dolphins from Eastern Tropical Pacific tuna purse seining, a different method from SASF. Future research includes investigating South Australian beach-washed carcasses in relation to the characteristics described in our study.

Novel, non-invasive methods for neurophysiological monitoring during rest behavior in phocids.

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One of the least understood physio-behavioral states for marine mammals is how and when they sleep, especially at sea. Studies examining sleep and rest in wild animals have traditionally relied on either behavioral observations exclusively or invasive surgical procedures. This study utilizes and develops two novel, non-invasive methods to investigate the neurophysiology of rest in phocids. It represents the first application of cerebral near-infrared spectroscopy (NIRS) on a northern elephant seal (n=1) as well as the first non-invasive electroencephalography (EEG) recordings of pinnipeds (n=5) using surface-mounted electrodes. Rest categories included inactive periods for dry-docked and submerged seals, as well as sedation for veterinary examination. NIRS recordings were performed on a freely-swimming wild juvenile elephant seal temporarily housed in a 5-foot pool at Long Marine Lab. NIRS data during 52 repetitive, restful (low-activity, often stationary) dives in the elephant seal revealed that peripheral vasoconstriction was insufficient to maintain constant levels of brain oxygenation, resulting in a mean decrease of -3.74 µmol Hb_{Oxy}*L^{-1}*min^{-1} (mean de-oxygenation rate weighted by dive duration with SD=±10.7 µmol Hb_{Oxy}*L^{-1}*min^{-1}). Furthermore, brain oxygenation does not monotonically decrease during a dive, possibly due to the release of additional pulsed oxygen stores. EEG recordings performed on five anaesthetized northern elephant seals investigated brain wave patterns during Telazol-induced anesthesia (with and without isoflurane maintenance), tested electrode configurations for future field applications, and revealed periods of delta slow wave activity closely resembling slow wave sleep in humans, but also periods of lower amplitude EEG characteristic of waking. In conclusion, variability in blood volume, oxygenation, and electrical activity during these different rest states suggests that the phocid brain is actively engaged in restorative mechanisms during sedentary periods that may explain both the ability and imperative of diving mammals to sleep during long transits at sea.

Booth in a box: An innovative tool to help right whales (Eubalaena glacialis).

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There are approximately 411 North Atlantic right whales in the world, of which around 100 are breeding females. The time to act for this species is now. The Year of the Right Whale is a project whose mission is to protect the North Atlantic right whale through celebration, education and action. The project consists of social media outreach, in-person events and fundraising initiatives to engage the public in learning about right whales and supporting recovery efforts. We will evaluate our efforts in 2020, when we reflect on our successes and hopefully have made progress on our goal of protecting North Atlantic right whales with a measurable decrease in threats to the species. A key strategy used in this campaign is the innovative "Booth in a Box," which includes tools to educate the public about right whales and engage them in protecting them. These include a right whale model, baleen/feeding activity, children's activity booklet, banners with facts, interactive games and talking points for the person staffing the table. This tool is freely available to organizations, whale watch companies, students, etc. to be used in fairs, festivals, schools and other venues. This will enable these organizations to provide an interactive, educational booth that can be staffed by a volunteer or other interested party, which provide booth visitors with concrete actions they can take to protect right whales. This presentation will discuss the components of the Booth in a Box, and successes and lessons learned so far.

Interactions between small-scale fisheries and marine mammals in the Eastern Mediterranean: Case studies from the South Adriatic and the Levantine Sea.

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In the Eastern Mediterranean Sea, bycatch rates are unknown, underestimated or seriously underreported, while information on fishing effort and marine mammal populations is widely absent. Yet, fishery is considered as one of the main threats on marine mammal populations in the Mediterranean Sea. It is, therefore, crucial to evaluate the magnitude of this threat to reveal possible impacts on the regional population status. The current pilot study aims to assess the extent of the interactions between small-scale fisheries and marine mammals in the Eastern Mediterranean Sea and intends to delve into the unexplored research niche that exists in the region; case studies from the Levantine Sea (Antalya Bay, Turkey) and the South Adriatic Sea (Montenegrin/Albanian coastline) were examined. The following methodology was chosen, representing a mix between quantitative and qualitative data-gathering: i) interviews with local fishermen, ii) spatial data on marine mammal distribution and iii) GPS logger data on small-scale fisheries operations. ArcGIS was used for habitat and fishing effort mapping. Overlap was observed between the core zones of targeted species distribution and the fishery territories in certain occasions. Gillnetting is the fishing method that was mostly implicated in bycatch in all study sites. The resulting overlap between fishing operations and marine mammal distribution poses a threat towards both directions: higher risk of species entanglement and economic burden on fishermen due to net destruction. At the same time, it reveals possible foraging grounds for marine mammals since in these areas there is high prey abundance. Lastly, by identifying the overlapping zones, specific management and conservation actions shall be proposed, with the aim to reduce bycatch pressure on key populations.

Interpreting multiple types of geospatial scientific information to protect marine mammals: A practical guide for decision-makers.

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Marine mammal protection is increasingly being carried out in a spatially explicit management context. Examples include Biologically Important Areas in the United States, the Marine Noise Registry developed under the European Marine Strategy Framework Directive, and the international effort to identify Important Marine Mammal Areas led by the IUCN Marine Mammal Protected Area Task Force. In turn, the scientific community has responded by advancing the generation and collation of geospatial data, and developing geospatial analytical techniques to inform these efforts, including habitat models, satellite telemetry data, genetic information, and expert opinion. The protection of marine mammals is best informed through the collective consideration of these multiple types of geospatial information; however, differences in methodologies, spatial and temporal scales, and associated caveats and uncertainties can make it extremely challenging for decision-makers to interpret and apply them collectively in their decision-making. To help address this challenge, an international collaboration of scientists has developed an interactive and practical guidance

document for decision-makers to assist in the evaluation of different types of geospatial scientific data, and to aid in its collective interpretation and application to marine mammal protection efforts. Accompanying the guidance document, interactive ESRI Storymaps provide decision-makers with hands-on opportunities to become familiar with different types and qualities of geospatial data, and to work through case studies demonstrating how geospatial data may be integrated to inform a variety of decision-making contexts. The intent behind the guidance document is not to provide yet another management tool, but rather to be broadly applicable to a wide variety of protection processes across regions and scales. The guidance will therefore help to ensure that geospatial scientific information is more comprehensively and effectively used in marine mammal protection efforts.

Annual variation in female humpback whale (Megaptera novaeangliae) pregnancy rates, calving rates and physiological state linked to changes in prey abundance in the Gulf of St Lawrence

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The consequences of shifting environmental conditions as a result of climate change are of concern for many marine mammal populations worldwide. Data on the reproduction, health and energetic status of individual animals from long-term sampling efforts can help to monitor these potential consequences. Steroid hormones were extracted from blubber biopsy samples (n = 185) collected from photo-identified female humpback whales (*Megaptera novaeangliae*) between 2004 and 2017 in the Gulf of St Lawrence, Canada. Blubber progesterone was quantified as a marker of pregnancy status. Cortisol, a glucocorticoid hormone involved in the long-term regulation of both energy intake and storage, was quantified as an indicator of physiological state. Annual calving rates declined over the study period (range between 0.05 and 0.52 with an overall decrease of 0.02 per year), and were positively correlated with pregnancy rates in the previous year (linear model: $p < 0.001$). The decline in observed calving rates could therefore be the result of decreased pregnancy rates rather than a reduction in calf survival.

Environmental data were collated from satellite images (phytoplankton bloom magnitude), the Atlantic Zone Monitoring Program (zooplankton biomass and copepods abundances) and fish stock assessments (herring and mackerel). A generalised additive model (GAM) showed that blubber cortisol concentrations were negatively correlated with the magnitude of the spring phytoplankton bloom, the summer zooplankton biomass, and the herring spawning stock biomass in the previous year (GAM: $R^2 = 0.3$, deviance explained = 38%). These relationships were strongest for pregnant and immature females showing that the highest cortisol concentrations, indicating increased lipolysis, were measured in years of reduced primary productivity and prey abundance particularly for these reproductive classes. A better understanding of baleen whale reproductive and physiological state, and their links to environmental conditions is fundamental to appreciate how populations will be affected by changing environments in the coming decades.

Common minke whale calves (Balaenoptera acutorostrata) in high latitudes of the Northeast Atlantic during winter months

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Common minke whales (*Balaenoptera acutorostrata*) occur throughout the North Atlantic, yet their seasonal movements and the location of important habitats are poorly known. Adults and sub-adult minke whales are sighted throughout the year in Irish waters, however mother-calf pairs are rarely observed during winter months. A common hypothesis describes autumnal migration to low latitude breeding and calving grounds, although this has previously been challenged. Herein we report high latitude winter sightings of unweaned minke whale calves in offshore waters of the northeast Atlantic, almost 200 km from the Irish coast. These sightings support the hypothesis that some individuals within a population forego the typical migration route by over-wintering and

perhaps calving at high latitudes in the warmer waters of the North Atlantic Drift. The inherent difficulties of offshore visual data collection during winter months challenges our understanding of species distribution and habitat use. Thus, rare sightings such as these reported are vital for understanding animal movement ecology and implementing appropriate conservation measures.

Migration patterns of eastern North Atlantic humpback whales revealed by satellite tracks

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Humpback whales undertake long seasonal migrations between high latitude feeding and low latitude breeding grounds. Whilst whales in the northeast Atlantic follow this pattern, fundamental questions about their migrations and their year-round distribution remains unknown. During the last nine winters, humpback whales unexpectedly aggregated in coastal waters of northern Norway, likely in response to a shift in overwintering herring distribution. This might constitute a new or re-established stop-over site on the southward migration of whales feeding in the Barents Sea. We present the first direct observation of eastern North Atlantic humpback whale migration to breeding grounds based on Argos derived tracks. We obtained tracks from individuals instrumented during winters 2015-2019 on the coast of northern Norway (19) and on the Barents Sea feeding grounds in September 2018 (10). Part of the individuals from the Barents Sea headed towards the Norwegian coast, while others traveled directly towards the Caribbean. Recorded destinations spanned from the Dominican Republic to Dominica, with large variation in observed migration routes between Greenland and the Norwegian shelf. Importantly, the migratory timing of these whales appears off-beat, as they arrive delayed in regards to the main breeding season described for the Caribbean. This mismatch in timing suggests that individuals may travel to behaviorally distinct population segments within the southeast Caribbean with a later breeding season. Furthermore, some individuals were observed to turn back immediately or before arriving to known breeding grounds. This suggests that these individuals might not breed that given year but instead migrate to give birth. Therefore we assessed individual re-sighting history and sex, as well as pregnancy status of the tracked individuals. Finally, we compared our results to observations from the known distribution range in the eastern North Atlantic, which was so far primarily based on photo identification.

From competition to collaboration: Automated identification of right whales.

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Photo identification plays a major role in endangered species research and conservation, and recent developments in artificial intelligence promise to increase the efficiency of matching photographs to known individuals. At the last Society for Marine Mammalogy conference, we presented on the Kaggle data science competition to automate the identification of endangered North Atlantic right whales based on 7,000 aerial images. The winning algorithms developed by

deepsense.ai were able to identify individuals with 87% accuracy using a series of convolutional neural networks. Since that time we have brought in many more collaborators as we move from prototyping to production. Leveraging the existing infrastructure by Wild Me, the developers of Flukebook, we are creating a website platform that allows biologists with no machine learning expertise to automatically identify right whales. New models will be generated using both the winning deepsense.ai algorithms and the Wild Me HotSpotter algorithm (used for humpbacks, jaguar, giraffe, and other species). Given the morphological similarity between the North Atlantic right whale and closely related Southern right whale, our goal is to create an automatic identification system that will benefit right whale researchers worldwide. The updated dataset will incorporate the largest long-term photo-identification catalogs including over 400,000 images from the United States and Canada curated by the New England Aquarium; 12,311 images from Australia from Curtin University; 8,461 images from South Africa from the University of Pretoria; 8,952 images from Argentina from the University of Utah; 5473 images from Brazil from Instituto Australis; and 2,913 images from New Zealand from the University of Otago. We hope to encourage researchers to embrace data collaboration and computer vision to increase our understanding of wild populations

High risk, high reward: Sex-specific foraging and life history strategies of northern elephant seals.

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Sexual selection and intraspecific niche divergence can result in behavioral, morphological, and physiological differences between the sexes. These sex-specific differences often lead to diverse strategies for maximizing fitness. Northern elephant seals (*Mirounga angustirostris*) are an extreme example of sexual dimorphism, as males possess dramatic secondary sexual characteristics and are nearly three times the size of females. Using a large comparative dataset of male (n=39) and female (n=152) seals, we examined sex-specific foraging and life history patterns exhibited by northern elephant seals and evaluated the costs and benefits of different behavioral strategies. We analyzed 37 metrics relating to the geospatial patterns, diving behavior, and foraging success of each seal. We found little to no overlap between male and female foraging strategies (ANOVA, $p \leq 0.05$), indicating that the sexes occupy different ecological niches. Males have small foraging areas in which they undertake benthic foraging dives (mean: 230 ± 95m) on the continental shelf. In contrast, females have large foraging areas and undertake deep pelagic foraging dives (mean: 550 ± 44m) to capture mesopelagic prey in the open ocean. Males are extremely consistent in their at-sea behavior, while females exhibit seasonal variability in behavior. These sex-specific differences appear to result in a trade-off between foraging success and survival. Males have higher foraging success (measured as greater mass and energy gain; ANOVA, $p \leq 0.05$), yet also have a higher at-sea mortality rate (males: 44%, females: 13%). Males likely adopt a riskier strategy to attain and maintain the large body sizes required to compete for mating opportunities, while females adopt a risk-adverse strategy that maximizes lifetime reproductive success. The balance between risk and reward is a fundamental selective pressure shaping the life history of northern elephant seals, driving intraspecific differences in behavior between the sexes of this extremely dimorphic species.

Behavior of adult female and its weaned calf in the Amazonian manatee after releasing into the river.

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The Amazonian manatee (*Trichechus inunguis*) is endemic to the Amazon region. Amazonian manatees are difficult to observe in natural environments, due to the water turbidity and their solitary, cryptic behavior. In this study, we monitored the behavior of adult female and its weaned male calf after releasing into the river, in order to investigate the interaction between mother and its weaned pup. Adult female was rescued and kept in captivity for 10 years and its calf was born

in the semi-captive lake, 2 years in captivity. We confirmed that the male calf was already weaned before releasing. Two types of animal-born digital recorders were attached to the adult female in order to monitor the behavior and underwater sounds, and behavioral recorder was attached to the male calf. Recording duration was 2.5 and 0.5 days in adult female and male calf, respectively. Four hours after releasing, male calf seemed to separate from his mother. He showed repeated diving, while adult female stayed shallower depth. After 13 hours, he seemed to rejoin with his mother. Vocalizations were confirmed in the adult female, and it continued for up to two days. But there was no vocal response by another manatees. We considered that mother seemed to have a high motivation to communicate with its calf after weaning. And weaned calf also seemed to have a motivation to reunite with his mother, while he showed join and separate without vocal response to his mother.

First-ever vocalization study of wild Indo-Pacific Bottlenose dolphins (Tursiops aduncus) at Jeju Island, Republic of Korea: Whistle characteristics and its response to ambient noise.

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Dolphin vocalization mediates complex social behavior and navigation while obtaining environmental information. Indo-Pacific bottlenose dolphins, *Tursiops aduncus*, produce numerous type of acoustic emissions including clicks, pulsed signals, and tonal calls. Tonal calls are the diverse repertoire of whistles and signature whistles for communication which exhibits a variation between geographically separated populations of *T. aduncus*. Additionally, recent studies have shown the importance of both natural and anthropogenic ambient noise on the whistle production of dolphin in response to signal masking. First, the baseline study of whistle characteristic was conducted by measuring the following: whistle class, contour inflections, harmonics, beginning frequency, end frequency, maximum frequency, minimum frequency, and duration. Whistles occurred in the frequency range of 0.011-23.34 kHz (mean 6.75-11.7 kHz) with durations of 0.32 – 1.86 s. The whistle characteristics are significantly different from the closely located *T. aduncus* population in Japan and showed a less whistle contour complexity. To further investigate the whistle production, we examined the effect of concurrent natural and anthropogenic ambient noise (both the broadband signal (20 Hz–24 kHz) and one-third-octave band levels centered on frequencies from 20 Hz to 22.4 kHz). The linear regression analysis indicated that the minimum frequency had significant positive relationships with the ambient noise present at the time of the whistles. Also, an increase in anthropogenic noise mainly caused by dolphin-watching vessels below the dolphin's call bandwidth resulted in shifting up of the produced whistles on the minimum frequency, and reduction of whistle repetition. The noise induced change of dolphin acoustic behavior may reduce the overall effectiveness of communication. Additionally, the shift in whistle characteristic during a continuous disturbance by dolphin-watching vessels may result in group separation and significant loss of energy in efforts for group cohesion.

Fishing for change- development alternative fishing gear for saving the Vaquita

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The Vaquita porpoise (*Phocoena sinus*) has almost been driven to extinction by incidental by-catches in gillnet fisheries in the Upper Gulf of California. The Mexican government has thus banned the use of gillnets in the entire distribution range of the Vaquita. To find alternative fishing gears for the enrolled gillnet fishers, a project developing vaquita-friendly fish pots was pushed forward by ECOFT (Expert Committee on Fishing Technologies) supported by the Mexican government and in collaboration with WWF Mexico. The aim was to create fish pots, as an alternative fishing gear to gillnets in the no-gillnet zone of the Upper Gulf of California. To ensure the best performance of the pots, an experiment was conducted testing three different baits available to the fishers. Three baits were selected and tested in the area of San Luis Gonzaga, Mexico. Fish attraction were recorded using GoPro cameras. The results showed that in daylight Flat-iron Herring proved to be the most effective bait, whereas the results from the night were inconclusive. In total three different pot types were tested, two floating and one bottom standing. The results showed that the bottom standing pot design had the highest fish catches but the species caught were very area dependent. During the trials the average catch per fishing journey was 25 kg. Total catches, however, can be improved by increasing the numbers of pots used, placing the pots at the best possible fishing

grounds and leave the pots in the water with optimal soak times. Thus if fishers are willing and capable of fulfilling these requirements, fish pots can turn out profitable and become a viable alternative to gillnets in the Upper Gulf of California. However, more trials are needed to conclude this.

Assessing cetacean presence and ocean noise in and around one of the busiest waterways in the world: The New York Harbor.

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One of the most pressing concerns for marine conservation at national and international levels is increasing ocean noise from anthropogenic sources. Potential impacts range from acute injury to sub-lethal effects , all of which may have long term impacts on population viability. Along the Atlantic coast, NOAA has declared an Unusual Mortality Event (UME) for humpback whales, minke whales and North Atlantic right whales (2017-2019), which may be directly or indirectly related to anthropogenic impacts. Within the New York Bight, cetaceans have been documented with increasing frequency in recent years. However, there is currently only limited knowledge of the ambient noise environment and potential impacts, and particularly within the New York Harbor; the largest and busiest port on the Eastern Seaboard. SoundTrap ST300 recorders were deployed in the lower New York harbor area over a one-year period from 2018-2019. Both automated and manual methods were used to document cetacean species presence, distribution, and soundscape characteristics. To visualize measured sound levels at each location, broadband and third-octave band spectrograms were generated using the RavenX toolbox , and a quantitative assessment of median equivalent sound levels ($L_{eq\text{-}50}$) was conducted for each location. A variety of sound sources were identified including anthropogenic activity, natural biological noise sources, cetacean vocalizations, and fish vocalizations. Overall, anthropogenic noise was pervasive throughout the study area, and measured sound levels were elevated compared to other locations within New York (3-12 dB re 1µPa higher in low frequency bands). Therefore, cetaceans within the New Harbor are exposed to noise levels that are often associated with long-term physiological and behavioral effects due to anthropogenic sound. With the growing conservation concerns for cetaceans within New York waters, this project along with additional monitoring efforts will help to inform marine spatial planning initiatives to ensure sustainable ocean use.

Coordination is key: Vocal mechanisms underlying cooperation in dolphins.

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Cooperation can be found across all levels of biological organization, from eukaryotic cells to social insects, as well as from baboons to humans. Yet studies have demonstrated that animals can behave in ways that function cooperatively without actively and intentionally cooperating. Previously, we have shown that bottlenose dolphins can understand their partner's role in a cooperative context by using a cooperative button-pressing task that requires precise behavioral synchronization. During this task members of a dyad were required to swim across a lagoon and each press their own underwater button simultaneously (within a 1 s time window), whether sent together or with a delay between partners of 1–20 s. We showed that individuals will work together with extreme precision, even when they have to wait for their partner. Here, we investigate how bottlenose dolphins use vocal signals to coordinate their behavior during these cooperative tasks. A male dyad was exposed to six trial phases that increased in task difficulty, ranging from the cooperative partners being sent together, to progressive delays between partners, to partners being unable to see one another when they pressed their buttons. We recorded the vocal behavior of the dyad during these tasks and used acoustic localization to determine how individuals used vocal signals when working together. Overall, the dolphins were more likely to exchange whistles prior to pressing their buttons during successful trial than during unsuccessful trials. Moreover, in phases that the dolphins found particularly difficult (as measured by success rate), they produced more whistles during successful trials than during unsuccessful trials. Bottlenose dolphins are well known for cooperating extensively in the wild and for their vocal flexibility. Our results suggest that vocal signals play a key role in coordinating their cooperative efforts.

Hormones reflect impacts of reproductive rest on subsequent pregnancy in Weddell seals

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A season of reproductive rest increases chances that an adult female Weddell seal (*Leptonychotes weddellii*) will successfully give birth during the optimal timeframe the following year. To identify mechanisms linking offspring production to subsequent birth likelihood and timing, this study compares reproductive physiology between female Weddell seals that skipped pupping in the current year (skip females, n=45) and seals that recently gave birth (postpartum females, n=87). Serum concentrations of reproductive hormones (progesterone, estrogen, luteinizing hormone (LH), follicle stimulating hormone (FSH), and prolactin), body mass, and body condition (% lipid) were measured during the breeding period and early gestation. Field ultrasonography was used to image ovaries and detect early pregnancies, while range-wide censuses conducted the next year determined if females successfully gave birth. Progesterone and LH concentrations indicated that skip females ovulated before postpartum seals (mean date=November 19 vs. December 1), which corresponded with earlier parturition the following year. This forward shift in reproductive timing likely benefits seals that tend to give birth late in the season; later birthing seals ovulated at fewer days postpartum (χ^2=6.286, p=0.012) and were less likely to bring pregnancies to term (χ^2 =3.999, p=0.0455), suggesting tight temporal constraints on reproduction. During early gestation, serum concentrations of both progesterone and estrogen were higher ($F_{1,91}$=7.12, p=0.002; $F_{1,84}$=37.18, p<0.0001) in skip females than postpartum seals. While skip females were larger and fatter than postpartum females during the breeding period and early gestation (all p<0.0001), neither mass nor condition had a significant direct link to the likelihood of subsequent pupping. This study reveals that advanced ovulation timing and elevated sex steroid levels may enhance future reproductive success in Weddell seals that skipped pup production in a given year. Phenotypic plasticity in reproductive timing may be an important mechanism by which Weddell seals and other long-lived species buffer consequences of environmental change.

Fatty acids and diving development: Age class and sex differences in skeletal muscle fatty acid compositions the northern elephant seal (Mirounga angustirostris).

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Fatty acid oxidation provides approximately 90% of energetic requirements in northern elephant seals (NES), yet little is known about the composition of their skeletal muscle fatty acids (FAs). Here, we report the skeletal muscle FA composition of NES within different age classes (adults {AD}, 1-year olds {1YR}, weaned pups {WP}) and sex. We analyzed 207 samples, spanning from 2012-2016, via GC-FID (WP n=102, 1yr n=32, AD n=73; male n=116, female n=91). A subset of 17 FAs, accounting for 93% of FAs, were normalized and transformed using an additive logratio transformation. Saturated fatty acids (SFAs) dominated muscle tissue (74%-78%) in all age classes, monounsaturated fatty acids (MUFAs, 10-15%) were the second most abundant and polyunsaturated fatty acids (PUFAs) were the least abundant (9-11%). Muscle tissue was predominantly composed of four FAs, C16:0, C18:0, C18:1n9c and C20:2 (78% total FA). Multivariate analysis (MANOVA) of FA groups (SFA, MUFA, PUFA) and chain-length/double-bond groups (MC-SFAC18:0, MC- MUFAC18:1 and PUFA) both indicated a significant effect of age class (F[4,248]= 14.40 p<0.0001; F[8,244]= 8.46,p<0.0001) but not sex. A significant effect for age class (F[4,388]=31.22,p<0.001) and sex (F[2,194]= 8.92, p<0.0001) was reported within the 17 FAs. Univariate statistics with post hoc tests revealed WP significantly differed from both AD/1YR across FA groups and chain-length/double-bond groups (p<0.0001 for all ANOVA/Tukeys; no sig difference for AD*1YR). Weaned pups drove the model sex effects through four FAs (ANOVA, F[1,1138]=1.21,p<0.000; Tukeys p<0.0001 C11:0, C16:0, C16:1, C17:0). WP differed from AD/1YR for 8 FAs (5 SFAs, 2 MUFAs, 1 PUFA, Bonferroni p<0.017) and differed from 1YR for 4 FAs (1 SFA, 2 MUFAs, 1 PUFA, Bonferroni p<0.017). These results suggest there may be a developmental difference in NES skeletal muscle FAs, possibly relating to the period of diving development that occurs between weaning and becoming a deep diving NES.

The 'Dolphin pump'? Dolphins mediate the translocation and recycling of allochthonous oceanic nutrient subsidies to coral reefs.
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Cetaceans have the potential to consume considerable portions of total production in a system owing to their large body sizes, relatively high trophic levels, potentially high abundances, and high metabolic rates. In addition to their ecosystem roles as predators, cetaceans may also be important vectors of nutrient transport within or between habitats or ecosystems. Cetacean-mediated nutrients can enhance primary production and increase population sizes of lower trophic level organisms beyond what *in-situ* nutrient availability could support. We investigated the importance of two abundant tropical dolphins (*Stenella longirostris* and *Stenella attenuata*) around an Indian Ocean coral island in mediating the transport and recycling of nutrients in a nitrogen-limited coral reef ecosystem. Both species forage primarily at night on offshore epi- and mesopelagic prey and rest, travel and socialize along the outer slopes of the barrier reef. Based on field estimates of dolphin abundance combined with data on metabolic and excretion rates, we estimated that these species excrete 55,240 kg N yr^{-1} along the barrier reef. We determined the relative contribution of dolphin excretions and local organic matter sources to reef species using a Bayesian stable isotope mixing model based on particular organic matter (POM), seagrass and dolphin samples collected from the lagoon, reefs and open-ocean. Concentration-dependent percent contributions of each source were calculated for several fish species occurring in seagrass, inner reef and outer reef habitats. Model results suggest that dolphin-derived nitrogen contributes to 10-45% of the available production in the reef food web, and the primary route appears to be via nitrogen uptake by benthic producers. Our results are an order of magnitude higher than those published for other predators such as sharks on similar reef systems. Because dolphins bring offshore nitrogen to the oligotrophic reef systems, these fluxes may be critical to supporting the productivity of coral reef communities.

Statistical modelling for spatio-temporal population mixture for marine mammal species
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A new approach for spatio-temporal modelling is proposed for expressing population mixture over space and time. The study was inspired by the fact that migration patterns of multiple populations of marine mammal species could change over years, which implies that their spatial mixture patterns can accordingly be altered dynamically. The study was also motivated by another fact that understanding of spatial and temporal population structure is one of crucial components for developing better conservation and management plans. Some mixture models are constructed with simple random walk models or latent random fields accounting for spatio-temporal patterns in mixture probabilities. Here, use of genetic data is assumed, and an integrated likelihood function is employed for parameter estimation and model selection. Parameters of primary interest are those describing the population mixture. In addition, other many population specific parameters such as genetic allele frequencies are also estimated simultaneously. As a computational algorithm, software implementing a Laplace approximation with automatic differentiation is used. Better precision for estimating mixture pattern by models with spatial and temporal structure was demonstrated compared to conventional approaches. In addition to the theoretical aspects, the practicability to marine mammal species is discussed. Furthermore, a possible extension of model with use of other non-genetic sources of information such as morphometric data is examined to increase the information on the mixture since genetic differentiation between populations tend to be weak for marine mammal species.

Increasing the understanding of multispecies feeding events in marine hotspots by medium term instrumentation and tracking.
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From a case study focusing on surface rate behavior of minke whales, we tracked a vhf tagged whale for multiple days in the waters of Svalbard , Norway, in 2007. The tag was deployed with the whale-tag-launcher ARTS (Aerial Remote Tag System), and the tracking was enabled by the radio directionfinder ADF setup with 4 yagi antennas. The VHF tag had a signal path of 240ppm, with 30ms signals length, which gave 2 to 6 signals during a surfacing. The data was sampled by a custom made voice recorder including a computer linked to a GPS and a microphone. However, the spinoff of this project was all what the tag did not record, and is what we would like to spotlight here. That would be the time between and the residence time at different Hotspots, and the mix of co-

species and other species in these Hotspots observed during the 116 hours tracking event. A total of 193 nm biological track was registered during these days, crossing the waters of Storfjorden, mapping in total 4 Hotspots, with a residence time varying between 2 hours to 12 hours, with all from very dense areas to wider spacing. Observations during the presence in Hotspots 1-4, included for all a number of minke whales and fin whales, while for some also humpback whales, white-beaked dolphins, harp seals, fulmars and kittiwakes. Multiple returning pattern of the tagged whale, was observed for Hotspot 1 (residence time 6 hours) and Hotspot 4 (residence time 12 hours). The development of tag sensors, tag attachment and tracking abilities the last decade, make now this type of ecological approach to an ecosystem using an individual tagged whale as a biological track possible, and would also be extensively strengthened while combined with prey field mapping and trawl sampling along the track.

Geometric morphometric analysis of sterna of harbor porpoises using spherical harmonics (SPHARM) reveal heteromorphic variation

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Harbor porpoises are the only cetacean species, which reproduces in German waters of the North Sea and Baltic Sea. Previous morphometric analysis on the skull of harbor porpoises have shown that porpoises in the North Sea, the Danish Straits and the Baltic Proper can be separated into three different populations. This separation is supported by microsatellite and single-nucleotide polymorphism genetic analysis. However, morphological and genetic variation between subpopulations in the Baltic Sea are small. To establish and optimize a geometric morphometric approach and to increase the accuracy of a potential separation we used SPHARM (Sperical Harmonics; Center for Computational Biology and Bioinformatics, Indiana University School of Medicine) on a simple bone with high variability: the sternum of the harbor porpoises. Fourty sterna of porpoises found in the North Sea, the Danish Straits and the Baltic Proper were scanned using a computer tomograph (SOMATOM Definition AS, Siemens). The resulting picture files were processed with Amira (FEI, ZIB, Mercury Computer Systems, Berlin). A three-dimensional volume rendering of each bone was used to generate a triangular mesh surface. On this surface nine pre-defined homologue three-dimensional landmarks were positioned. The triangular mesh surface including the landmarks was used as a template for the SPHARM-models. SPHARM calculates a complex Fourier-Transformations of spherical harmonics coefficients used for a bone comparison based on principal component analysis. The results show allometric scaling and no separation of the three different populations, sex. Therefore, a geometric-morphometry analysis of the sternum of the harbor porpoise cannot be used to establish population differences based on this limited dataset. However, the methodology can now be implemented for other bone material and may allow for more morphological discriminative power for instance using the skull.

Whales, dolphins, fish, and boats: Why defining the contributors of soundscapes in Australian Marine Parks matters for policy and management.

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Soundscape characterization of acoustic data results in information on the biological and anthropogenic contributors present within marine environments. Marine mammals and other soniferous species provide a unique view of the status and health of environments, such as marine parks, in which changes can be tracked through long-term monitoring. Quantifying the level of human activity in and around Australian Marine Parks is an essential component for managers concerned with enforcing restrictions on illegal activities. Understanding the degree of vessel activity at sea is challenging, especially for large

and remote parks. However, vessels have well-documented acoustical signatures and vessel noise is often omnipresent in coastal marine soundscapes. As an initial step to establishing a broader monitoring program, three SoundTrap 300 recorders were deployed for one month in two marine parks off of southeastern Australia between July and September 2018, one recorder in Cod Grounds Marine Park and two in Solitary Islands Marine Park (SIMP). Using Raven Pro 2.0, the hourly presence of humpback whale (*Megaptera novaeangliae*) song; delphinid clicks, burst pulses, and whistles; fish chorusing; and vessel noise was identified for both parks. Relative distance of vessel sounds were modelled to estimate the number of vessels within the boundary of SIMP. Results showed that humpback whales and snapping shrimp were continuously present, while delphinids were present more at night and were more often present in SIMP. Fish chorus patterns differed between parks. Forty-three discrete vessels were considered to have occurred within SIMP. Vessel presence inside of the park was greatest on weekdays (Tuesday through Thursday) between 05:00 and 18:00 AEST, peaking in the latter 3 hours. Individual vessels typically stayed in the park for less than one hour. These data develop new methods aimed at understanding vessel behavior and compliance as well as providing baseline information on marine biological activity.

Adapting nanopore (MinION) next generation sequencing methods to detect novel RNA virus genomes in Alaskan marine mammal species.

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Emergence of RNA viral infections is a growing concern among North American marine mammal species. Morbillivirus (phocine and cetacean distemper viruses) and influenza A viruses are pathogenic, negative sense RNA viruses that cause serious infections in the respiratory, gastrointestinal and sometimes central nervous systems. In 2018, an unusual mortality event was declared for over 2000 grey seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) stranded along the Atlantic coast (NOAA UME 67). Preliminary diagnostic PCR indicates mortality was caused by phocine distemper virus (PDV). Influenza A was also detected, however, it is not considered the main cause of mortality. Preliminary detection of PDV and influenza A, using PCR diagnostic assays, have been observed in Alaskan marine mammals including PDV in sea otters (*Enhydra lutris*) and morbillivirus in a Steller sea lion (*Eumetopias jubatus)*. Existing viral diagnostic methods are not optimized for understanding genotypic variation, pathogenicity or transmission properties across different wildlife interfaces. We are analyzing complete virus genomes using Oxford Nanopore Technologies (MinION) to map virus variation among different geographical regions. MinION offers an inexpensive and portable means of genetic sequencing virus genotypes and host biomarkers in real time. Following an RNA extraction and purification protocol, we are using a panel of virus-specific primers in a multi-segment (MS-RTPCR) for influenza or tiling (RT-PCR) approach for PDV to obtain full genome amplicons as input cDNA in library preparation. Raw nanopore read data is processed and mapped to viral genomes using reference-based assembly, to generate consensus sequences for evolutionary analysis and virus genome annotation. Analysis of viral genome variation is crucial for understanding virulence, transmission, and susceptibility of marine mammal species to RNA viruses among different environmental interfaces. This data can be integrated into the evaluation of how ecological and physiological factors impact the health of marine mammal populations in Alaska.

Educating marine audiences about the benefits of rope-less fishing technologies

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Rope-less fishing technologies for fixed fishing gear could provide a long-term solution to the annual entanglement and death of dozens of large whales in US waters. Whales are especially vulnerable to the millions of fixed gear lobster and crab traps fished in the waters of New England, the Gulf of Maine, and from California to Alaska. The development and use of rope-less fishing gear systems may prove essential to the recovery of the endangered North Atlantic Right Whale, as their population numbers just 411 animals (2018 NOAA estimate). Photographic studies conducted by scientists have shown that 85% have signs of rope scars and necropsies of dead animals show that fishing entanglement is the highest documented cause of mortality.

A variety of rope-less designs concepts have and are being rapidly developed. The first may have been a system called the Fiobouy that was invented by Fiomarine systems in Tasmania, Australia in the 1990's. A Washington State non-profit engineering team called SMELTs, Sea Mammal Education Learning Technology Society collaborating with Teledyne technologies, and have built a lift bag system that is launched be an acoustic signal from the surface and inflates an airbag. Dessert Star Systems in California have completed an acoustic release control unit system and free rope-less fishing app for fishermen to track their gear. Many other systems are being developed around the world.

Feasibility of using reduced breaking strength ropes (1700 lbf) in fixed gear fisheries

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NOAA Fisheries, with guidance from the Atlantic Large Whale Take Reduction Team, is developing regulations to mitigate entanglement impacts from buoy lines on North Atlantic right whales (Eubalaena glacialis) which will include broad implementation of 1700lb breaking strength ropes in waters off New England. To evaluate the efficacy of 1700lb ropes we conducted studies to determine 1) if reduced breaking strength rope can ensure effective hauling of fishing gear and 2) whether entanglement complexity and injury severity is likely to be reduced for any whale that gets entangled in 1700lb ropes. First, we modeled hauling loads under normal fishing operations with OrcaFlex software to inform strategies for at-sea testing. We then conducted at-sea testing of "south shore sleeves", a rope strength modification developed by the South Shore Lobster Fishermen's Association in Massachusetts. Sleeves manufactured by Novatec Braids at <1700lb breaking strength were integrated every 40 feet into buoy lines of nearshore trap fisheries. This modified gear was used by eight fishermen on lobster gear, in waters up to 300 feet deep, and compared to adjacent gear rigged with regular strength buoy lines of ~3900lb breaking strength. No significant increase of gear loss was detected after a season of fishing with modified gear (8.5% control vs 11.8% modified gear loss) and all but one of the ropes parted during soaking versus hauling. In parallel, the Virtual Whale Entanglement Simulator showed how these ropes could be parted by whales while maintaining sufficient strength for typical fishing operations. Additional studies are underway with the offshore lobster fishery to evaluate deeper water gear configurations that would support the use of 1700lb ropes. In the years following rule implementation, careful documentation of rope length, entanglement complexity, injury severity and resulting fate of all entangled large whales will be necessary for evaluating effectiveness of this gear.

Decreasing sociality of male sperm whales (Physeter macrocephalus) with age.

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Male sperm whales leave their natal unit before sexual maturity, and form groups consisting of males of about the same age. The sizes of male groups generally become smaller as the members get older. However, how group size decreases with growth is not understood. We examined the change in social relationships with growth among male sperm whales using photo-identification data obtained in the Goto Submarine Canyon and Nemuro Strait, Japan. We photographed flukes of whales for individual identification and measured the distance to the whales using a laser-rangefinder to estimate their body lengths. The correlations between network statistics calculated from association indices with body length were examined for 45 animals from which body length estimates were obtained more than once. All network statistics were negatively correlated with body length (Spearman's rank correlation test, $p<0.05$). Association strength continued to decrease as males aged, while maximum association indices and clustering coefficients declined rapidly when between 13 - 14 m long. However, our previous study found that large males can have long-term social relationships. Thus, males have less social life but do not become completely asocial as they age. Although the cue for changes in sociality is unknown, the decline at 13 - 14 m coincides approximately with sexual maturity and may relate to changes in the endocrine system such as testosterone level.

Occurrence of false killer whales in Ryukyu Archipelago including Okinawa Islands, Japan.

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Although false killer whales are known to distribute throughout the tropical and subtropical waters in the world, the species is one of lesser unknown large odontocete. Using the data corrected in Ryukyu Archipelago from 1982 to 2019, we investigated the seasonal occurrence, the distribution, the water depth and the group size of false killer whales in this area. We analyzed the stranding data corrected between 1982 and 2019 as well as the boat sighting data corrected between 2007 and 2019. As a result, 10 stranding and 37 sighting records were confirmed within the years. According to both records, false killer whales were found only during winter to summer (December to August) and none of them was observed in fall (September to November) when the mode of occurrence was in the beginning of spring (February and March). 78% of all the sightings were confirmed in the water depth shallower than 350m. The estimated number of individuals in a group was 1 to 100 (Average=17.3). A total of 536 estimated individuals were observed in 37 groups and 90.3% of all the groups were groups of less than 40 individuals which shows similar trend reported in Hawaii and New Zealand. We identified 68 individuals with the photographs of distinctive scars or characters on their dorsal fins and all of them were observed only once within the 12 years of the survey period. In Hawaii and New Zealand, same individuals were observed several times in years. Our result indicating that the false killer whales in Ryukyu Archipelago are possibly migrating seasonally around this area and move to the other areas mainly during the fall seasons. Although, the results obtained basic information on false killer whales in Ryukyu Archipelago, further researches are essential to understand more detailed life history of this species in this area.

Observation of the periodontal tissue of Delphinidae.

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Mammalian teeth are in the oral cavity and used to hold, cut, crush, and grind food. What plays an important role in these performances is not only the dental hard tissue, but also periodontal tissue that support the teeth. The periodontal ligaments are collagenous fibers that fill the gap between the roots and the alveolar bone (periodontal space) . The ligaments hold the teeth in the alveolar sockets and function as a cushion giving mobility to the teeth. In the odontocetes, the alveolar sockets are large for the size of teeth. This was assumed to mean the development of periodontal ligaments.

In the present study, we observed dolphins teeth roots, periodontal ligaments, and alveolar sockets with a light microscope for decalcified tissue section and micro CT. We used some samples of Delphinidae which died of accidents or diseases in some aquariums. As a result, the alveolar bone was crude and spongy like the cancellous bone. The lamina dura which is a hard layer of the alveolar surface was not observed and the teeth are attached directly to the spongy bone. These characters are not found in other common mammals. The periodontal ligaments were highly developed and composed of two layers. The inner layer fibers radially spread out from the cementum like humans and mice. On the other hand, the outer layer fibers penetrate the spongy bone and run in a complicated way. Between these inner and outer layers, a thick nerve fiber bundles were running that could not be found in human or mice periodontal ligaments. Therefore, we conclude that there is a possibility that the periodontal ligaments of dolphins are more sensitive than humans and mice.

Mixed-species groups of common dolphins and bottlenose dolphins in the Alonissos National Park, Greece.

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Mixed species groups (MSG) occur among different mammalian species, ranging from related species to species belonging to different orders. MSG may enhance foraging and predator avoidance, or provide social benefits. These advantages, however, may not be equally distributed between the participating species. Although the habitat of Mediterranean common dolphins *Delphinus delphis* (Dd) and common bottlenose dolphins *Tursiops truncatus* (Tt) often overlaps, few reports exist of associations between these species. During boat-based visual surveys conducted in the summers of 2017 and 2018, we recorded 8 MSG of Dd and Tt in the coastal waters of the National Marine Park of Alonissos, Northern Sporades, Greece. These MSG accounted for 8 of a total of 29 Dd encounters (28%), and 8 of a total of

10 Tt encounters (80%). MSG, observed in non-consecutive days, were composed of 6–15 individuals, with a prevalence of either species. The longest observation lasted 94 min, though animals were associated when encountered and remained associated when left. Of a total of 471 min of MSG observations, 125 min (27%) included both species engaged in the schooling and chasing of epipelagic fish (possibly sardines) near the surface. Observations, occurring over depths ranging between 3 and 250 m, and distances from shore ranging between 3 and 3720 m, also included synchronous diving or travelling. The largest MSG (12 Dd, 3 Tt) included one Dd calf and one Tt juvenile (the latter being observed swimming in a tight formation with adult common dolphins, and bowriding with them). Future research should focus on the reasons behind these associations, their potential benefits, the occurrence of actual cooperation between the two species, and whether MSG may occur as a consequence of common dolphin low and declining abundance.

Diving apart together: Exploration of vertical call propagation in long-finned pilot whales.

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Staying in touch can be of vital importance for animals that live in social groups. To keep contact, far-reaching acoustic signals can be critical, especially when the habitat is dark or cluttered with vegetation. Many deep diving odontocetes live in long-term stable social groups at the surface. However, these groups temporarily separate when they start foraging individually at depth. Odontocetes are well-known for their vocal behaviour, but are their calls detectable over large vertical distances? We combined theoretical and empirical investigation to investigate if calls can be used for detecting group members in long-finned pilot whales (*Globicephala melas*). First, we used acoustic propagation modelling to investigate the potential for call detectability over the distance that our study animals were separated. Second, we verified our propagation model with acoustic recordings from simultaneously tagged pilot whale pairs in the same social group. Finally, we investigated how call characteristics and environmental features at the producer and the receiver were correlated to call detectability on the tag. Our results showed that long-finned pilot whales can indeed use calls to detect each other when vertically separated. Predicted call detection was correlated to variation in call characteristics such as duration and amplitude, while ambient noise levels also affected detection. Combined, our results reveal how acoustic signals can aid sociality and how different acoustic features can contribute to optimal signal transmission in a deep-diving whale. Since ambient noise levels in the ocean have increased due to anthropogenic activities, it is important to get more understanding of the acoustic detection between foraging pilot whale group members and how their behaviour might be affected by the changing ambient noise.

Visual, tactile, and acoustic interactions among captive Belugas (Delphinapterus leucas)

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Belugas (*Delphinapterus leucas*) exchange distinct pulsed sounds, called "creaking calls (Mishima et al. 2018); however, information about their visual and tactile interactions are limited. We compared visual, tactile, and acoustic interactions among captive belugas to reveal how belugas use such communications. We obtained 14-h recordings via simultaneous video and stereo sound recordings for 11 days from two adult females and one juvenile male in 2015 and from one juvenile male and one female calf in 2018 using two hydrophones at Shimane Aquarium, Japan. An initiator and a receiver were observed for visual and tactile behaviors. Furthermore, an initiator who produced the first creaking call and a responder who called back by creaking call within 1 s were identified using time difference in sound arrival. Visual (pair swim, head jerk, mouth open, flee, face, watch, pass-by, approach, and leave), tactile (bite and contact), and other behaviors (play catch) were significantly higher between calves than between an adult and a calf and between adults (Kruskal-Wallis test: $x2 = 32.66$, 38.21, and 17.73, respectively, $p < 0.001$, Tukey-Kramer HSD test:$\alpha = 0.05$). In contrast, sound exchanges were significantly higher between adults than between others (Kruskal-Wallis test: $x2 = 27.24$, $p < 0.001$;

Tukey-Kramer HSD test: $\alpha = 0.05$). Time differences between the first and the next creaking calls (call-call response) were significantly shorter than those between a creaking call and the next behavior (call-behavior response), between a behavior and the next creaking call (behavior-call response), and a between behavior and the next behavior (behavior-behavior response) (Mann-Whitney U test with Bonferroni correction: $p < 0.01$), implying that belugas respond to the creaking calls of others by creaking calls, and not by other behaviors. Overall, belugas maintain their relationship by sound exchange among adults and by visual or tactile behaviors among calves.

First report of striped dolphin (Stenella coeruleoalba) strandings due to dolphin morbillivirus in Greece.

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In the past 30 years cetacean morbilliviruses (CeMV) infections have occurred in many marine mammal populations around the world. In the Mediterranean Sea, two major episodes of mortalities due to *dolphin morbillivirus* have been reported in striped dolphins (*Stenella coeruleoalba)* in the years 1990-1992 and 2006-2008. In this report we present the resurgence of *morbillivirus* in the Greek coasts in the year 2018. Unusual strandings of 70 striped dolphins occurred between April and October 2018 in the Aegean and Ionian Sea, East Mediterranean. Fourteen striped dolphins (12 males and 2 females) stranded alive; they were calves or juveniles (0,80 - 1,60m tbl). All had similar clinical signs, sush as disorientation, swimming and diving impairment, tremors, depression and lethargy. Despite supportive first aid treatment, within a few hours all animals showed severe neurological signs, e.g convulsions, seizures, and died. Full necropsy and tissue sampling were feasible in 12 animals. These dolphins showed moderate body nutritional condition and empty stomachs. Gross lesions were mainly found in the central nervous, respiratory, lymphoid and digestive systems. Heavy parasitism was present in 7 animals. Brain, lung, kidney, liver, lymph node, spleen, heart and skin samples were taken for histopathological and virological testing. Histopathology consistently revealed lesions characteristic of morbillivirus-associated bronchointerstitial pneumonia and non-suppurative meningoencephalitis. Inflammatory and degenerative lesions in liver, intestine and lymph nodes were also frequent findings. Samples from nine dolphins were examined using a real-time RT-PCR targeting the P/V/C gene of morbillivirus. The assay was strongly positive in brain and lung of all (9/9). Sequencing of a 359bp amplicon showed 99% identity with homologous genomic regions of dolphin morbillivirus (DMV) strains. These findingssupport the diagnosis of a fatal acute and subacute DMV infection in the striped dolphinpopulations of the Eastern Mediterranean Sea for the first time. Further research to characterize the virus strain and its epidemiology is needed.

An evaluation of the ecological needs and effects of a potential sea otter reintroduction to Oregon, USA.

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From the mid-1960's to early 1970's, managers translocated sea otters (*Enhydra lutris*) from coastlines along southwest and southcentral Alaska

to regions where sea otters were extirpated during the Maritime Fur Trade. Translocations to Southeast Alaska, British Columbia and Washington were successful and have led to growing populations. The translocation to Oregon was not successful, as sea otters disappeared shortly following release. There is renewed interest in reintroducing sea otters to Oregon. Managers seek improved understanding of the potential for coastal habitats to support sea otter populations and factors likely to affect translocation success. We meet this need by investigating the population potential for sea otters in Oregon. We adapted and applied a recently-developed model of habitat-specific carrying capacity (*K*) for southern sea otters to estimate spatial variation in potential sea otter abundance (at equilibrium). The habitat-based *K* model predicts equilibrium densities at small spatial scales as a function of a suite of habitat features (substrate type and bathymetric profiles) and environmental variables (kelp abundance and nearshore productivity). Areas of high predicted population potential were related to a range of human activities (i.e. fisheries effort, protected areas) to assess their degree of spatial proximity and overlap. We predict a total carrying capacity of 4,665 (95% CI: 1,487, 10,771) sea otters in Oregon. We found more suitable habitat along the southern coast, from Coos Bay to the Oregon-California state border, near a marine reserve and high crab fishing effort. We anticipate minimal interaction between sea otters and human activities on the central and northern coastlines due to the region's relatively lower predicted sea otter densities. This study provides the first carrying capacity estimate of sea otters in Oregon. Results could inform and support the reintroduction decision-making process, and help set targets and expectations for sea otter recovery and future research in Oregon.

Changes in sei whale feeding habits in response to fish species replacement in the western North Pacific during 2002-2018.

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Western North Pacific sei whales *Balaenoptera borealis* feed on a wide spectrum of prey species such as zooplankton and small pelagic fish. The prey availability of sei whales is highly dependent on small pelagic fish transported into offshore waters of the western North Pacific by the Kuroshio Current. Japanese anchovy *Engraulis japonicus* and Japanese sardine *Sardinops melanostictus* are important prey species for sei whales in this region. These fish species fluctuate in occurrence and abundance in decadal scales. Recent fisheries catch statistics show that Japanese anchovy was replaced by Japanese sardine during the last decade in the western North Pacific. We hypothesized that, given their greater availability, Japanese sardines should be the predominant prey species for sei whale in the recent years. This study investigates the changes in feeding habits of the sei whales in response to decadal-scale changes in prey species. The study was based on the analysis of stomach contents of sei whales sampled by the Japanese Whale Research programmes during the 2002-2018 summer seasons. The prey species of sei whale in the 2000's was diverse including Japanese anchovy, copepods (*Neocalanus plumchrus, N. cristatus*), euphausiids and mackerels (*Scomber japonicus*, *S. australasicus*). The occurrence of Japanese anchovy in the stomachs decreased after 2011, and the Japanese sardine became the predominant fish prey species after 2013. In fact, in 2017 and 2018, the diversity of prey species decreased and the Japanese sardine became the most dominant prey species for sei whales. Changes in the diversity of prey species in sei whales reflected changes in the availability of prey species through the years. As expected, the intensive feeding of sei whale on Japanese sardine in the last decade, especially in 2017 and 2018, reflected the greater abundance and availability of this fish species in the western North Pacific.

Group composition and social behavior of migrating Steller Sea Lions on a haul-out in Hokkaido, Japan.

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The Asian stock of Steller sea lions (SSLs) reproduces at rookeries in Russia from June to September, and the group migrates to the Hokkaido coast from October to May every year. However, little is known about how the group is maintained and socially composed except that the mother-infant relationship continues during the migration period. In this study, we characterized the group composition and social behavior of SSLs during their migration. SSLs use a haul-out (tiny island) to rest in the waters off Otaru, Hokkaido, Japan between feedings on herring from January to March. We continuously observed SSLs on the haul-out using a 24-hour fixed-point video camera for 55 days. We analyzed the number and hourly pattern of landings and entry into the water at the haul-out. We also classified the groups into types by comparing the group type with that seen at and around the rookeries. The social behavior of the

SSLs was classified and the frequency of the behavior was analyzed. SSLs became active and entered the water at sunrise around 0600–0700, and they returned to the haul-out at sunset at 1700–2000. The average number on the haul-out changed from 65 to 34, from January to March. It was revealed that the SSL group types were similar to those in the rookeries. We named the groups Bachelor-like (a dozen bulls only), Idle Bull-like (a few bulls), and the Harem-shifted group (several bulls, 5–10 females and 5–6 pups). Affiliative behavior was frequently seen between mothers and pups in the Harem-shifted group. Threatening behavior was shown as territorial behavior against SSLs from the haul-out. In the present study, we clarified the group composition and sociality of SSLs during migration, and showed that some SSL groups may be sequential between the Russian rookeries and the Hokkaido haul-out.

Revelations from an aerial perspective: How hungry whales work smarter not harder.

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Humpback whales are well known for their exceptionally long pectoral fins. To date, most studies that have addressed this have considered their role in shallow water navigation, rapid acceleration, and increased maneuverability. In this study, we document a novel behavior in which humpbacks use their pectorals during bubble net feeding at salmon hatchery release sites and surrounding areas. Specifically, we analyzed video footage and photographic sequences of two whales to assess the use of humpback whale pectorals during foraging events. Innovative technology has enabled aerial perspectives that greatly enhance our understanding about how these dynamic animals aggregate, capture, and manipulate prey. From aerial footage, we found a previously undocumented technique regarding the use of humpback whale pectorals during a bubble net feeding event. We defined this technique as "pectoral herding", with two methods of execution: "horizontal pectoral herding" and "vertical pectoral herding". We believe that the whales we observed used a bubble net to corral hatchery-released salmon, followed by directed movements of their pectorals to establish a secondary boundary that further condenses the prey field, increasing foraging efficiency. These observations demonstrate that prey aggregation and capture is not limited to movements of the head, caudal peduncle, and tail flukes. Our results also provide evidence of behavioral plasticity and suggest considerable variation among individual humpback whale foraging strategies. Further investigation would enhance our understanding about whether the pectoral herding technique is used as a principle foraging tool across the species as well as the conditions that promote its use.

Cetacean Virtopsy: 3D surface and radiological scanning and reconstruction for postmortem investigation

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In the course of the pioneering virtopsy-driven stranding response program in Hong Kong and adjacent waters, virtopsy using three-dimensional surface scanning (3DSS), computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonography have been implemented to provide supplementary or complementary information to conventional necropsy. Since March 2014, a total of 189 deceased cetaceans were confirmed in the Hong Kong waters. Either whole body or regional virtopsy of 150 carcasses were performed and analyzed for biological health and profile investigations. Two cetacean species, *Sousa chinensis* and *Neophocaena phocaenoides* (55 males, 64 females, 31 unknown sex; calf to adult; 50–365 cm in length), were included, with the carcass code ranging from 1–5.

The 3DSS protocol had been developed to provide surface documentation of external patterned injuries. CT was useful in diagnosing fatal hemorrhage, organ herniation, and pathological gas collection, as well as determining the number, shapes and characteristics of the fractures sites and the direction of external force. MRI was effective in evaluating soft tissue lesions, musculoskeletal injuries, integrity of spinal cord and brain herniation. Radiological assessment of the degree of epiphyseal fusion/ossification at postcranial skeleton allowed individual age-at-death estimation, supplementing the data obtained by dental growth layer group pattern. Gradual increment of postmortem gas accumulation in various tissues could be quantified with CT, which might gain invaluable insight to the individual death interval.

This long-term study demonstrated virtopsy is a potentially powerful tool, providing non-invasive and objective measurements to supplement the necroscopic findings for cetacean biological health

and profiles investigation. Virtopsy could also facilitate veterinary personnel to perform image-guided target specimen necropsy and sampling for histology and toxicology. The calibrated 3-D documentation and analysis of virtopsy findings would lead to qualitative improvements in conventional
necropsy, and pose precise conservation measure of local cetaceans caused by anthropogenic and natural injury.

Abundance estimation of Striped dolphins (Stenella coeruleoalba): Spatial models with distance sampling methods in the area of the Hellenic Trench.

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Abundance estimations for cetacean populations are fundamental for conservation and wildlife management. Striped dolphins (*Stenella coeruleoalba*) are one of the most common species in the Eastern Mediterranean Sea and have been set as "Vulnerable" by the IUCN Red List. There has been no abundance estimate for striped dolphins in the Greeks seas before. In this study, we used spatial distance sampling method, in a series of data obtained from 12 years survey effort (1999-2009, 2014) along the Hellenic Trench. In total, 143 schools (2158 individuals) of striped dolphins were recorded in 13172 km surveyed. Detection function estimation was fitted to perpendicular distance data using R and "Distance package. The covariates that were consider as explanatory variables for detection were depth, swell, beaufort, and group size of dolphins observed. The best fitted detection function was a hazard rate model with covariates, affecting the detectability, sea state condition and group size of dolphins (AIC=1766.003). Detection probability derived from the detection function for the overall surveys was on average p= 4.394 (CV= 0.2911879) and the goodness of fit test showed a good fit: Cramer-Von Mises test (unweighted) statistic= 0.176656, p-value = 0.317657. The effective strip half width (ESW) is 773.07m with detection probability p=0.5. Spatial models were constructed using generalized additive models. For the abundance estimation the environmental covariates that were admitted were chl-α, sea surface temperature (SST) and sea level anomaly (SLA) and oceanographic features depth, slope and distance from shore. Results will confirm the main sub areas with high density and suitable habitat conditions for the species and variances amongst the years. Abundance trends suggest a decrease in striped dolphins within the study area. These findings will highlight the importance of long-term studies to understand variation in abundance in a specific area, subject to conservation activities.

Marine mammals in a changing Arctic

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Ice-associated marine mammals in the Arctic are threatened by sea ice habitat loss combined with "borealization" of Arctic food webs and increasing human traffic. Seasonally resident marine mammals are expanding northward, increasing the risk of competition with resident species. Killer whales are spending extended seasons in previously ice-covered areas. In the Barents Sea region, where sea ice losses are occurring 2-4x as rapidly as elsewhere in the Arctic, ringed seals are maintaining body condition, but they are working harder to access food – diving more and resting less - home ranges are shrinking and they are increasingly tightly associated with glacier fronts. In other areas, condition and reproductive declines have been documented. Some species are displaying dietary changes and shifting their behaviour in adaptive ways. For example, white whales have shifted some of their foraging effort away from their normal feeding areas in front of tidal glaciers in the Svalbard Archipelago toward open-water areas in fjords, likely reflecting a broadening of their diet. Polar bears (and other species) are shifting their distributions to track suitable foraging and denning habitats. In the Barents Region this has meant abandoning southerly denning areas that no longer have sea ice connections at the time of den entrance and shifting foraging northward and eastward. Bears in this region are also spending more time on land and they are eating more terrestrial food (ground nesting bird in particular). Monitoring marine mammal populations in the decades ahead will be essential to determine the plasticity possessed by endemic Arctic species and to inform management and policy bodies regarding their status and conservation needs.

Where to find Spitsbergen bowhead whales – and why?

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The Spitsbergen bowhead whale stock was hunted almost to extinction in the first commercial whaling venture, starting in the early 1600s. At the start of the 21st century, it was assumed to consist of some few 10s and currently it remains classified as Endangered by the IUCN. In recent decades, passive acoustic monitoring in Fram Strait has given cause for optimism regarding recovery of the stock; revealing a nearly year-round presence of bowheads in the region and significant song diversity in winter. Additionally, aerial surveys in the marginal ice zone north of Svalbard from the Russian border westwards during August 2015, estimated 343 (CI 136-862) bowhead whales in the 52,000 km^2 ice-covered study area; no animals were seen from the ship, whales were sighted only on transect lines inside the ice. These data stimulated the initiation of a tagging program using helicopters to locate individuals in this highly ice-affiliated population of bowheads. During the summers of 2017 and 2018, 25 satellite transmitters were deployed on bowhead whales between East Greenland and Svalbard. Over the course of each year, the tagged whales ranged broadly, covering much or all of the range historically suggested for the Spitsbergen stock, extending from coastal waters of East Greenland eastward beyond the islands of the Franz Josef Land Archipelago. Commonly occurring time gaps in the records prevented interpolation of locations into full period tracks; so positions were used in habitat analyses. A combination of LME and GAMMs determined that bathymetry (deep water), shelf-slope-angle (steep), distance to the coast (often far offshore), SST (longer stays in cold water) and distance to ice edges (strong preference for ice-covered areas) were all important habitat features for this stock in some seasons. Unlike other bowhead populations, the winter distribution of this stock is more northerly than its summer distribution.

Is there a time and place to start singing? The timing and distribution of western North Atlantic humpback whale singing behavior in the fall.

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Humpback whale songs have been described in detail on winter breeding grounds and studies of singing on high latitude summer feeding grounds have increased. However, there are few descriptions of the timing and manner of song onset during the fall. This limits our ability to understand the drivers of song onset, be they spatial, temporal, environmental, hormonal, and/or cultural. Recent work indicates that humpback whales display an acoustic transition period during the fall when song fragments are produced prior to an increasing prevalence of full song. We describe here an expansion of that study, documenting the ontogeny of humpback whale singing behavior through one fall season at locations along the western North Atlantic coast (inshore and offshore) ranging from Newfoundland and Labrador, Canada to Massachusetts, U.S.A. We tested the null hypothesis that singing behaviour begins simultaneously at all locations irrespective of variables such as latitude or depth. Seven bottom-mounted acoustic recorders collected data during September to December 2015. Humpback whale acoustic occurrence was determined through the manual review of the middle 60-70 sec of contiguous to near-contiguous 10-11 min acoustic files. The highest quality recordings were selected for acoustic behaviour analysis and the occurrence of non-song, song fragment, and full song vocal behaviour was verified. Results thus far suggest that singing behaviour begins in early September but is rare until the first week of October when it becomes common at all locations. Song fragments ceased by early November to early December and full songs continued until humpback whale vocalizations ceased or recordings ended. These results suggest that the trigger for humpback singing behaviour is related to time of year, with potential links to seasonal cultural and/or hormonal shifts, rather than latitude which would be more indicative of environmental triggers (e.g. length of day, depth, or sea surface temperature).

The biogeography of common bottlenose dolphins (T. truncatus) of the southwestern USA and Mexico.

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Common bottlenose dolphins (*Tursiops truncatus*) inhabit tropical and temperate waters worldwide and frequently occupy urbanized, coastal environments. Off the west coast of the United States this species occurs as genetically distinct coastal and offshore ecotypes. The coastal ecotype generally occurs in waters < 1 km from shore between at least northern Baja California, Mexico and northern California. The offshore ecotype occurs > 2 km from shore, spanning at least the entire Pacific coast of the United States. The biogeographically distinct distributions of these two ecotypes are well-suited for comparative analysis of ecological drivers related to habitat selection, distribution patterns and exposure to threats. Since the 1980s over 430 standardized surveys for coastal ecotype dolphins have been conducted, resulting in 6,136 sightings. Starting in 1992, periodic surveys for offshore ecotype dolphins have been conducted off southern California, resulting in over 50 sightings. These sighting data are used to develop species distribution models for each ecotype relative to sea surface temperature, depth, upwelling, temporal factors, and large-scale oceanographic indices (e.g., El Niño) and describe and compare factors influencing observed distribution patterns between 1981 and 2015. Although these ecotypes are influenced by similar large-scale environmental processes within the greater California Current Ecosystem, we predict that smaller-scale static and dynamic environmental patterns impact distribution patterns in divergent ways. For instance, results will be provided describing how the distribution of coastal and offshore ecotype dolphins were affected by nine El Niño events that occurred in the study area between 1983 and 2010. With multiple marine protected areas along the California coastline, the results of this study will help guide proactive population and habitat management actions designed to maintain healthy bottlenose dolphin populations.

Discrimination of vortex ring size by a stationary harbour seal (Phoca vitulina)

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Harbour seals perceive water disturbances with their highly sensitive vibrissae. This enables them to track hydrodynamic trails left behind by prey fish. These trails differ depending on the fish species, the fish's body shape, size, and swimming style and may thus reveal information about their generator. Most of these complex fish trails contain vortex rings as a main hydrodynamic component. Even single vortex rings, created in C-start escape responses or other natural situations, might convey useful information to a seal. In a previous study we could show the ability of blindfolded stationary harbour seals to perceive a variety of artificially generated single vortex rings and furthermore that they are able to analyse them regarding directional information. As vortex ring size correlates with the size of a potential prey fish, it can be considered important information for a seal. In this study, the harbour seal's ability to differentiate two vortex rings based on their size has been investigated. In a pool two vortex ring generators were fixed under water on either side of a point directly ahead of the stationary seal. Single vortex rings with predefined sizes, velocities, and accelerations similar to those found in natural fish wakes were generated consecutively by each generator. One of the two vortex rings travelling to the seal's vibrissae was bigger than the other one. The animal had to identify the bigger vortex ring and responded by pushing its snout against one of two response targets in a left/right forced choice procedure. The seal was able to successfully differentiate vortex rings at least to a size difference of 17.63 mm. In natural situations in which no complex hydrodynamic trail is available, the ability to successfully analyse single vortex rings regarding their size by using hydrodynamic reception should be advantageous for harbour seals when hunting fish.

Global phylogeography and genetic diversity of the long-finned pilot whale Globicephala melas, with new data from the Southeast Pacific

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The matrilineal long-finned pilot whale presents an antitropical distribution in temperate to cold waters and is divided in two subspecies. *Globicephala melas edwardii* is found in the Southern Hemisphere, while *G. m. melas* is restricted to the North Atlantic and Mediterranean. To date, population genetic and phylogeographic studies on this species have included localities around most of its Northern Hemisphere distribution, while in the Southern Hemisphere only the Southwest Pacific has been included in such studies. Here we add new genetic data (n=90) from the unsampled Southeastern Pacific to the published sequences, obtained from two mass strandings in the Chilean Patagonia. Low mitochondrial and nuclear diversity was encountered in this new area, as previously reported for other localities. Four haplotypes were found, with only one new for the species. In the global dataset, fifteen haplotypes were detected, underlining the low diversity of the species. As previously reported, both subspecies shared two haplotypes and presented a strong phylogeographic structure (Snn phylogeographic test =0.830, P<0.001). The current geographic distribution of this species has been related to dispersal and colonization events associated to the Last Glacial Maximum. Using the complete genetic dataset and Approximate Bayesian Calculations, this study supported this historical biogeographic scenario. Approximate dates were estimated for the range expansion at around 18.200 years ago and the subsequent post-LGM distribution split and growth 9.750 years ago. From a taxonomic perspective, even if genetic analyses do not support the subspecies category, this study endorses the incipient divergence process between both hemispheres. Thus maintaining their status and addressing them as *Demographically Independent Populations* is recommended.

Welfare and cognitive bias in captive killer whales (Orcinus orca).

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Robust methods to assess nonhuman animal emotion are essential for ensuring the welfare of animals under human care. A promising tool for assessing animals' emotional states is the cognitive bias test. It measures an individual's tendency to judge ambiguous information based on its emotional state or mood. In humans, cognitive biases are known as "optimism" and "pessimism" and it has been shown that being more optimistic is correlated to better subjective well-being. The cognitive bias as a tool to evaluate animals' emotional states has been implemented in a number of mammals and birds, and very recently for bottlenose dolphins (*Tursiops truncatus*) whereas generally very little research on welfare indicators has been conducted in cetaceans. In the present study, we describe for the first time the characteristics of cognitive biases in killer whales (*Orcinus orca*), evaluate intra-individual and inter-individual variability and investigate the interrelation between their cognitive bias and other potential welfare indicators (behaviour, hormones and vocalisations). Our study aids in establishing further research directions and can be practically implemented to improve the welfare of captive killer whales, e.g. by testing the efficiency of (cognitive) enrichment programs and training protocols.

Pearls before porpoises - modifying gillnets to reduce harbor porpoise bycatch.

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The interaction between gillnet fisheries and harbor porpoises has been recognized as a fatal problem since several decades. The exact reason, why harbor porpoises entangle in gillnets is not yet identified, but a possible explanation is that they fail to recognize the net as an obstacle they cannot penetrate. One way to mitigate this issue could be the addition of objects to the net at short distances to make it appear as a wall. In a systematic study, we modelled the acoustic reflectivity of a large range of objects for different combinations of object size and material properties. We found that acrylic glass spheres of less than 8mm in diameter resonate at 130 kHz. The spheres have a similar target strength as a table tennis ball and a qualitative sonar image of a prototype gillnet with spheres showed that the net becomes highly visible compared to a standard net. In order to quantify the efficacy of the spheres to reduce bycatch of harbor porpoises in a commercial setting, 10 paired hauls with 5 days of soak time each, are carried out in the

Turkish part of the Black Sea between June and September 2019. Two sets of gillnets (total: 2000m) are equipped with 8mm acrylic glass spheres at around 0.3m distance and compared to a standard net of the same length and equal net characteristics. A reduction of bycatch in the modified net while keeping fish catches constant could be a possible solution for the conflicting interests between nature conservation and fisheries.

Marine mammal and finfish predation explain high natural mortality and lack of stock recovery in weakfish

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Effective stock management relies on quantifying trophic interactions between marine mammals and fish. Despite fisheries regulation to reduce mortality, weakfish (*Cynoscion regalis*) along the United States Atlantic coast has experienced a precipitous population decline from 1982 to 2014. Concurrently, weakfish natural mortality (*M*) increased, yet the cause for the increase is poorly understood. We identified five primary predators based on published accounts of diet, and spatial and temporal distribution of weakfish during the winter and compared the predator consumption of weakfish with the biomass attributable to *M*. During 1982 to 2014, the biomass of weakfish consumed was estimated using population size, diet, and feeding rates; uncertainty for this estimate was calculated using a Monte Carlo resampling method. Predators consumed on average 6,767 t of weakfish (80% CI 1,740 to 14,388 t) during the time-series, of which 55% was consumed by common bottlenose dolphins (*Tursiops truncatus*), 21% by striped bass (*Morone saxatilis*), 17% by bluefish (*Pomatomus saltatrix*), and 7% by summer flounder (*Paralichthys dentatus*) and spiny dogfish (*Squalus acanthias*). The biomass attributable to *M* from the stock assessment and biomass of weakfish consumed during winter were similar, indicating that high estimates of *M* are realistic and the cause is most likely winter predation, as the average biomass from fishery landings in the last 10 years of the time-series was 29 times less than that by predator consumption. Predators consuming weakfish during their first winter have resulted in a recruitment bottleneck, as evidenced by relatively constant age-0 indices but decreasing trends in age-1 weakfish abundance during the time-series. The significant influence of predation on weakfish population dynamics and their importance as prey highlight the need for multi-species management.

Long-term population and distribution dynamics of an endangered Irrawaddy dolphin population under rapid industrial development in Balikpapan Bay, Indonesia.

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Worldwide, cetaceans are impacted by human activities and those populations that occur in shallow-nearshore habitats are particularly vulnerable. The paper presents a long-time study of the response of such a population, in terms of distribution and abundance, to widespread changes within a restricted environment.

Boat-based, line-transect surveys were conducted over 15 years between 2000-2015 (totaling 76 days and 4045 km), in Balikpapan Bay, East Kalimantan, Indonesia. Irrawaddy dolphins were sighted on 164 occasions. In addition, Indo-Pacific bottlenose dolphins, finless porpoise and dugongs were sighted here as well on 8, 6 and 10 occasions. The density of Irrawaddy dolphins was estimated through distance analysis. A decrease was noted from 0.47 dolphins/km2 in 2000-2001 (CV=25%) to 0.38 dolphins/km2 in 2008 (CV=30% as well as in 2015 (CV=29%). Mark-recapture analysis indicated a population size of 47 in 2008 (CL=46-56) and of 56 (CL=52-79) in 2015. Individuals exhibited high site-fidelity during this seven-years period.

In 2000-2002, Irrawaddy dolphins occurred throughout the Balikapapan bay area, however, by 2008-2015, the population appeared to be restricted entirely to the upstream areas of the bay. Throughout the study period, an increased boat presence, continued unsustainable fishing practices, ongoing pollution and sediment deposits were all observed and these factors likely contributed to changes in the Irrawaddy dolphin population density and distribution.

A large-scale oil spill, which took place on 31 March 2018 and affected an area of 20,000 ha, urges the need for continuous monitoring of the cetacean populations. The dependence of the Irrawaddy dolphin population on a relatively small and restricted habitat requires that appropriate coastal spatial planning be implemented as a matter of urgency. The area has been identified as an important marine mammal area by the IUCN-MMPA Taskforce and has been marked as such in the new government 20-years coastal spatial-planning document in progress, which may provide some concrete protection needed.

Human-related and natural body scars in coastal dolphins off Hurghada, Northern Red Sea, Egypt

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Anthropogenic threats to dolphins, particularly in coastal areas, are rapidly increasing worldwide. The prevalence of body injuries, scars, and entanglements can provide measures of human-related or natural threats, hence, offering important information for the assessment of conservation strategies. To date, most studies on the origin of body scars and injuries in living cetaceans have been investigated based on photographs collected in boat-based surveys or capture-release studies. However, boat-based surveys mainly permit the inspection of the dorsal body area of individuals and therefore, likely miss marks on lower lateral,- and ventral body parts. This study applied a worldwide unique research approach as it additionally included underwater-based research data collected during SCUBA dives, which allowed for complete body assessments. Photographs and videos from Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) off Hurghada, Northern Egyptian Red Sea, collected since 2009, were investigated based on descriptions in the public literature and cross-validations from experts. Marks were classified into injuries resulting from human interaction (fisheries interaction, boat strike) and natural sources (shark predation, intraspecific interaction). Results show that most dolphins with distinctive scars not attributable to conspecific interactions were of anthropogenic origin with fishing gear scars and entanglements being most prevalent, followed by boat injuries and shark-inflicted scars. This study contributes to the ever-growing body of evidence that human activities are considerable threats to coastal dolphins. Furthermore, it urges the necessity for discussing adequate conservation management strategies with regards to fisheries interaction and boating activities, including dolphin tourism.

Life histories of Galápagos sea Lions: Variation and population consequences.

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Variation in life history traits is directly linked to individual fitness. This interplay is complicated by environmental perturbations
in an unpredictable habitat. This study provides first estimates of life history traits and trade-offs of a tropical apex predator, the Galápagos sea lion (*Zalophus wollebaeki*). Thirteen years of individual data on birth mass, early growth and offspring, and environmental data allowed the examination of factors influencing reproductive performance of adult females and calculation of pupping rates. Females became primiparous between ages 4 and 9. Neither oceanographic nor body condition in the females' first year of life influenced age at primiparity. Age at primiparity had no effect on a female's birth rate, on average one pup every 2 years. Until age 6, females showed a lower birth rate (< 0.40). Fecundity was higher between age 6 and 14 (birth rate 0.40–0.48). We could not detect an influence of inter-annually differing oceanographic conditions on pupping rates.

We also used these life histories to estimate survival rates of females. Pups had the lowest (0.688) and adults the highest (0.825) average survival rate. Survival varied among years (pups: 0.345-0.872, juveniles: 0.484-0.939, adults: 0.665-0.979), but overall showed a significant decrease since 2003. Colder sea surface temperatures and large birth mass positively affected survival, particularly in pups.

From these estimates of vital rates, we constructed a demograpic matrix model. The population growth rate for the next 50 years was predicted to be clearly negative (λ=0.897) with a population decrease of 11% per annum. Prognoses worsened when environmental stochasticity, i.e. sea surface temperature anomalies (SSTa), was included (λ=0.840), and even more when the increase of 0.9°C in mean SST predicted by the IPCC was considered (λ=0.829). These results strongly

suggest that current conservation efforts are not adequate for the Galápagos sea lion.

Ranging patterns of indo-pacific humpback dolphins (Sousa chinensis) in the matang important marine mammal area in Perak, peninsular Malaysia.

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Understanding the ranging patterns of threatened wildlife is important for informed decisions for conservation. This study investigated the ranging patterns of Indo-Pacific humpback dolphins (*Sousa chinensis*) in the inshore and coastal waters of Matang, an IUCN Important Marine Mammal Area. Between 2013 and 2016, 14 boat-based surveys were conducted over 125 days to collect positional, photo-identification and behavioural data in the inshore, north coastal and south coastal strata. A total of 128 sightings were recorded and 206 distinctive individuals were identified. Of the 112 distinct individuals sighted inshore, 17 were sighted 10-17 times and their home range sizes varied between 75 and 287 km^2 (mean 191.1 ± 67.7 km^2). These individuals mostly occurred within 8 km from the estuaries, and moved alongshore for up to 50 km. Approximately 13 to 20 km farther from the estuaries, 28 and 66 distinct individuals were identified in the north and south coastal strata respectively and were mostly sighted once. Four individuals were sighted three to five times solely in the north coastal stratum, while three individuals were sighted three times solely in the south coastal stratum. Dolphins sighted close to the estuaries appeared to be locally resident with an alongshore range. Conversely, the dolphins sighted farther from the coast were not sighted in the estuaries and were likely to have a wide ranging area, ranging beyond the boundaries of the study area. Behavioural observations suggested that the inshore and north coastal strata serve as important feeding, foraging and nursing grounds, whereas the south coastal stratum were mostly used as socializing and mating grounds. Further investigation including genetics and social structure studies expanded beyond the study area are needed to verify if the individuals sighted in the north coastal, south coastal and inshore strata are distinct social units.

Overview of the U.S. navy's living marine resources (LMR) program.

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In its ongoing effort to reduce potential impacts to marine mammals while meeting at-sea training and testing requirements, the U.S. Navy supports both basic and applied research to improve the understanding of marine mammals in regards to occurrence, exposure, response, and consequences. The Living Marine Resources (LMR) program is responsible for funding applied research, and works to address the Navy's key research needs and transition the results and technologies for use within the Navy's at-sea environmental compliance and permitting processes, with the goals of improving marine species impact analysis (including marine mammal take estimates), mitigation measures, and monitoring capabilities. The program's funding priorities includes:

1. **Data to Support Risk Threshold Criteria**
2. **Improved collection and processing of protected species data in areas of Navy interest**
3. **MonitoringTechnology Demonstrations**
4. **Standards and Metrics**
5. **Education and Outreach, Emergent Opportunities**

The LMR program is currently heavily invested in data to support risk threshold criteria, passive acoustic monitoring technologies, and automated methods of acoustic data analysis. These methods are seen as an integral component of the Navy's current monitoring plan. We present an overview of the LMR program, how we fit and work with the Office of Naval Research's marine mammal program and the U.S. Navy's marine species monitoring program and LMR's current investments related to marine mammal research. The LMR program is sponsored by the Chief of Naval Operations (CNO) Energy and Environmental Readiness Division (N45) and managed by the Naval Facilities Engineering and Expeditionary Warfare Center (EXWC). An advisory committee, comprised of representatives within the US Navy, solicits input from all commands to establish the annual research needs

topics and assist in evaluating and selecting projects for funding.

Coping with climate change in conservation of the endangered Saimaa ringed seal

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The endangered Saimaa ringed seal (population size 400) is suffering from by-catch mortality and changing climate. Warming winters pose a risk for this population, which is dependent on snow and ice as its breeding habitat. For improving pup survival, novel conservation approaches have developed. Today we have a network of volunteers, who are willing to shovel snow for the seals and in 2014, over 95% of pups were born in man-made snowdrifts. The second ambitious step is enhancing seal breeding during winters with no ice by developing floating 'nest boxes'. The first pup was born in an Art-nest in 2018.

Opportunistic use of game camera traps to assess rare subpopulation of the Baltic ringed seal

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The southern subpopulations of the Baltic ringed seal (*Pusa hispida botnica*) in the Gulf of Riga, the Gulf of Finland and the Archipelago Sea are few in number and vulnerable. Climate change poses a significant threat, not only for the breeding success, but also for the reliability of population monitoring of those stocks. Mild winters hamper accurate aerial surveys and therefore novel monitoring approaches are urgently needed for estimating the status of these subpopulations. Ringed seals are known to have permanent, unique ring-shaped fur patterns, which enable individual identification and the usage of photo-ID approaches for varied purposes. During open water seasons May–August in 2016 to 2018, game cameras with time lap (one photo in every 60 minutes) were set in a terrestrial haul-out site in the Archipelago Sea (regional population estimate 200-300 seals) in south-western Finland. The biggest numbers of seals were recorded at the beginning of the study periods annually, which indicate moulting of the seals. Pilot camera-trapping effort produced some 30 500 images and around 30 individuals were identified manually, based mostly on fur patterns of their belly. Images provided new info on site fidelity, regional numbers and behaviour patterns of ringed seals. In addition, images showed long term and relatively common (over 15% of identified individuals) unknown sinus infection of the seals. This relatively small camera-trapping effort, provided already versatile info on the local seals. Therefore, camera trapping as a monitoring tool should be incorporated into long-term monitoring programs of rare southern ringed seal stocks.

Function of the tubercles on the dorsal ridge of East Asian finless porpoises, Neophocaena asiaeorientalis sunameri.

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East Asian finless porpoises (*Neophocaena asiaeorientalis sunameri*) have numerous tubercles on their specific dorsal ridge. However, their function is still unknown. In this study, we examined the tubercles histologically to consider their function.

The tubercle had conic shape with approximately 1 mm in diameter at its base and 0.5 mm height. In the dorsal ridge area (tubercle area), the epidermal layer except tubercles was constituted of the cells having nucleus, showing that the region is keratinized incompletely and soft. Contrarily, the tubercles were composed of the cells lacking nucleus and less stained by HE staining. Therefore, it is indicated that the tubercle is keratinized completely and very hard. In addition, there are many mechanoreceptors such as Meissner corpuscles, Krause end bulbs, and Golgi-Mazzoni corpuscles, which participate in senses of touch and pressure, in the dermal layer and the dermal papillae (10.5 mechanoreceptors per a section of 2 cm-square). Furthermore, some undescribed nerve corpuscles were found. Free nerve endings running into the epidermal layer were also confirmed. In the cervical area (non-tubercled area), the epidermal layer was composed of the incompletely keratinized cells. Few mechanoreceptors and few free nerve endings were also observed (0.15 mechanoreceptors per a section of 2 cm-square).

In summary, there are much more mechanoreceptors in the dorsal ridge are than in the cervical are. This result indicates that the dorsal ridge is a highly sensitive area for touch and/or pressure. It is also notable that conical and very hard tubercles on the soft epidermal layer. When the tubercles are touched or pressed, they are easy to roll, and the both ends of tubercle bottom must swing largely. In other words, it is considered that

the structure that the hard cones placed on the soft layer has a role to amplify the vibration.

Clicks-sound production and frequency determining mechanism in the head of small toothed whales; Functional morphology with acoustical interpretation.

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Click sounds of toothed whales are roughly divided into wide band (WB) clicks with a gentle peak in 30-100 kHz and narrow-band high-frequency (NBHF) clicks with one peak only around 130 kHz. The current ratio of extant NBHF species is about 20% of whole toothed whales. While the generating mechanism of NBHF clicks has been discussed for a long time, most conventional studies have been focused on the structural comparison of NBHF species and WB species without acoustical investigation. From the structure of sound source of clicks, NBHF clicks might be generated by reducing the bandwidth of WB clicks on the propagation path, leading to the idea of silencing mechanism in the lower frequency band by silencers. Some NBHF species had vestibular sacs with structure with many folds, considered to filter the sound with frequency below 100 kHz. Here, authors proposed this idea as “silencer hypothesis” and investigated the hypothesis in the current study. To confirm folded vestibular sacs work as a silencer, transmittance around the folded vestibular sacs of harbor porpoise (NBHF) and Dall’s porpoise (NBHF) were calculated. To confirm the head of NBHF species works as a high-pass filter, frequency response was measured by using real heads of melon-headed whale (WB) and harbor porpoise (NBHF). To confirm only NBHF species have folded vestibular sacs, anatomical structure of almost all toothed whales were investigated using conventional studies and CT data. From the results of these investigations, the silencer hypothesis was acoustically supported as a possible producing mechanism of NBHF clicks. However, the producing mechanism of NBHF clicks could not be explained by a single mechanism, because some NBHF species did not have any folded structures but quite similar head structure as WB species.

Recent status and fate of the north-eastern Mediterranean monk seal populations.

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The endangered Mediterranean monk seal (Monachus monachus) is represented by approximately 350-450 individuals in Eastern Mediterranean waters in the form of small, fragmented and isolated groups. The North-eastern Mediterranean coast of Turkey being the host to one of the last continuously breeding populations, has vital importance for the survival of the species. Small populations inhabiting this region have been studied extensively for the last 25 years. The recent surveys showed that fragmented populations are still exposed to severe threats as a consequence of anthropogenic impacts. Therefore, in this study we focused on three previously documented populations in the southern coast of Turkey to update their status by utilizing photo-identification method, to estimate the size of the populations with Champan modification, to elucidate the dispersal among populations and to test the impact of dispersal on the survival of the populations through population viability analysis (PVA). Within this context, 20 caves were monitored with infrared camera-traps between the years 2015 and 2018. 37 individuals were identified and the overall population size estimate was 37 ± 5 (95% CI) seals. Among them were three adult females mobile between Western and Central groups which makes the mobility range of seals almost six times larger than previously documented in the same region. When compared to former studies, mortality rates increased whilst fecundity rates decreased. The results of the PVA analysis showed that populations have higher chance of survival in the case of dispersal. However, both isolated and dispersed populations have failed to survive within the next 100 years. Moreover, PVA models were easily affected by carrying capacity which highlights the importance of breeding caves. Therefore, continuity of monitoring studies focusing on threats and establishing Marine Protected Areas considering the suitable seal habitats and mobility of seals has vital importance for the future of the species.

Virological and serological surveillance of canine morbillivirus infection among caspian seals (2007-2017).

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Canine morbillivirus (canine distemper virus, CDV) infection in Caspian seals (*Pusa caspica*) has been reported since 1997 and implicated in mass mortality of this species in 2000. CDV is caused by a single-stranded RNA virus of the family *Paramyxoviridae* (genus *Morbillivirus*). In this study, we conducted virological and serological survey of morbillivirus infection among Caspian seals. Samples as nasal, buccal, urogenital, rectal swabs and blood were collected from 176 animals in three locations of the Kazakhstan's part of the Caspian Sea between 2007 and 2017. The samples were screened for presence of morbilliviruses by reverse-transcriptase polymerase chain reaction (RT-PCR), with oligonucleotide primers targeting conserved sequences in the phosphoprotein (P) gene of that virus genus. As a result of RT-PCR, the expected products of 429 base pairs have been found in six seals out of 13 sampled in 2008. All the positive specimens belonged to individuals under two years old. The nucleotide sequences of PCR-positive for morbillivirus samples corresponded to those of CDV and differed from other members of the genus *Morbillivirus*. Further, no positive specimens were detected in the samples of broad timespan of subsequent years (2009-2017). Advanced research of materials using «Pan-paramyxovirus» primers specific for L-gene of all *Paramyxoviridae* family members also gave negative results. Since 2009, juvenile Caspian seals were not sampled and mostly large and adult animals were caught for satellite marking purposes. In serological analyses, antibodies to CDV were detected in six out of 74 seal serum samples (8.1%) harvested from 2007 to 2017. Three positives belonged to adult seals out of 18 sampled in 2016. The obtained data demonstrates possible decreasing trend of CDV prevalence in the Caspian seal population in last decade.

Do porpoises (Phocoena phocoena) have an acoustic fovea?

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Echolocation represents an interesting evolutionary case of simultaneous evolution of the relevant stimuli and the sensory apparatus. Some bats (Constant Frequency - CF bats) use Doppler information to detect fluttering prey and these bats possess an acoustic "fovea", an area of the basilar membrane with dense neural representation and very high filter quality (Q). Echolocation signals in these animals are extremely narrow band, and high Q values are associated with low hearing thresholds at very high frequencies. An acoustic fovea is often morphologically associated with areas of increased innervation in the cochlear. Such an area has also been reported in the harbour porpoise cochlear from anatomical investigations. Here we test the hypothesis that porpoises have an acoustic fovea by measuring click-evoked auditory responses in a captive harbour porpoise exposed to impulse responses from 3rd octave bandpass filters at ANSI-frequencies 64-160 kHz. Evoked response magnitudes were dramatically increased at 100 and 125 kHz compared to 64 and 80 kHz, despite documented very similar hearing thresholds between 16 and 140 kHz. This pattern supports the hypothesis of an acoustic fovea around 125 kHz by means of denser neural innervation. We suggest that this neural overrepresentation in the echolocation frequency range offer porpoises a high spontaneous firing rate so that there are always responsive neurons to encode dense target echoes across a large dynamic range. The function of the porpoise fovea is therefore quite different than those of Doppler detecting CF-bats, since porpoise clicks are stereotyped and far less narrowband (lower Q), and face relative predator-prey speeds that render them Doppler insensitive.

Mercury in toothed whales: A systematic review about brain concentrations and detoxification mechanisms.

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Toothed whales (Odontoceti) are top predators of marine food webs with great life expectancies and

they move around wide areas in the oceans, which makes them possible extraordinary accumulators of persistent pollutants. They also possess developed brains, complex behaviors and complicated social structures. Mercury can impair brain normal functioning; however, information about Hg in brain tissue and the derived neurotoxic effects in these species is extremely scarce. We carried out a systematic and extensive review in Google Scholar, PubMed & Scopus from 1976 to 2017 in order to know the status of this knowledge.We only found 22 studies which provided Hg concentration in brain tissue, which added up 333 samples from 9 different species worldwide. Odontocetes have shown to possess extremely high Hg concentrations in brain (range 0.00-48.60 ppm ww) and these values exceed in many cases those neurotoxicity thresholds established for mammals. High values of $[Hg_{liver}]/[Hg_{brain}]$ ratio were obtained (range 4.89-32.16; median 16.63), which could suggest liver Hg sequestration as a protection mechanism against neurotoxicity. Additionally, other detoxification pathways as MeHg demethylation also appear to be quite efficient in odontocetes brain, as MeHg proportion in relation to total Hg is much lower than in other species. Hg and Se antagonism mechanisms could explain the aforementioned. Thus, researchers have found very strong positive correlations of Hg and Se in brain of odontocetes. Furthermore, Se:Hg molar ratios in brain are usually higher than 1, which virtually implies Se availability to counteract Hg neurotoxicity. Nevertheless, despite these apparently efficient detoxification mechanisms, odontocetes accumulate extremely high amounts of Hg in their brains which could overwhelm their capacity to face its toxic effects. Further research is needed to consider whether mercury is causing a decline in health of toothed whales populations and by which mechanisms it does occur.

Comparative anatomy of the Saimaa (Pusa hispida saimensis) and Baltic (Pusa hispida botnica) ringed seals.

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The Saimaa ringed seal is thought to have originated from the Baltic ringed seal population and it became landlocked about 9500 years ago. Previous studies have shown that the genetic differentiation between these subspecies is high, and that the Saimaa ringed seal teeth have a unique molar phenotype compared to that of the Baltic ringed seal. The aim of our research was to study the anatomy of these seals further to see if there were also soft tissue differences. Our study methods include anatomical dissection, preparation of silicone casts, as well as computed tomography and magnetic resonance imaging. We found relatively few soft tissue differences between these subspecies. Nevertheless, the tongue of the Saimaa ringed seal was more oval-shaped and the bifid apex of the tongue more rounded than those of the Baltic ringed seal. The origination point of the first segmental bronchus from the right caudal lobar bronchus differed between these subspecies, and there was some variation in the number of floating ribs but more specimens are needed to confirm this. Combined with genetic analyses, our data will improve our understanding on the evolutionary phenomics of mammals.

Important area of conservation for cetaceans in southern iberian peninsula

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Information available on the occurrence and distribution of cetaceans in mainland Portugal is still very limited, despite recent efforts to improve this. Most information available comes from strandings, limited surveys and interviews with fishers. In the Southern coast of the country (Algarve) data is even scarcer although the region seems to be particularly interesting for marine megafauna species. Since 2010, we have been conducting surveys using a dedicated vessel and whale watching boats. Surveys take place over six months of the year allowing us to collect increasingly consistent data on the cetacean species present in the area. Eleven species were recorded corresponding to over 4500 sightings. Odontocetes accounted for the majority of the encounters, while only 3% were mysticetes. The common dolphin (*Delphinus delphis*) and the bottlenose dolphin (*Tursiops truncatus*) together made up 88% of the sightings. They were followed, in decreasing order of number of sightings, by the harbour porpoise (*Phocoena phocoena*), the minke whale (*Balaenoptera acutorostrata)*, the Risso's dolphin (*Grampus griseus*), the striped dolphin (*Stenella coeruleoalba*), the killer whale (*Orcinus orca*), the fin whale (*Balaenoptera physalus*), and finally the humpback whale (*Megaptera novaeangliae*), the long-finned pilot whale (*Globicephala melas*) and the sei whale (*Balaenoptera borealis*) each with the same number of encounters. Most records were within 15 nmi from shore, however, due to topographic features this distance corresponds to sizeable differences in depth. Records of the harbour porpoise and the bottlenose dolphin, protected species by the EC Habitats Directive

(92/43/EEC) and also considered in the ACCOBAMS agreement, were registered every year (ca. 250 and 1200 sightings in total, respectively) confirming both species are regular users of the area. Year-round surveys and more extensive habitat use studies are essential to provide a better assessment of the importance of this region for cetaceans and to fill the gap of knowledge.

Species distribution models and a novel approach to include soundscape information for north atlantic right whales and other species at risk

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Species distribution models (SDMs) are a suite of analytical tools that relate species distribution data with information on the environmental and/or spatial characteristics of those locations. SDMs typically incorporate static (e.g., depth and distance to shore) and dynamic (e.g., temperature, salinity, and distance to ephemeral oceanographic features) environmental variables that describe the physical environment. Despite the importance of the acoustic environment for marine organisms, acoustic attributes have not been incorporated into SDMs. Given recent developments in the field of marine acoustics, we can now provide richer insights into species distributions related to the acoustic environment. Our ability to use acoustic detections of marine mammals in SDMs is challenged by the uncertainties inherent in passive acoustic data such as animals being present but silent and masking during periods of increased ambient noise in addition to variability in detection distances of animal calls due to the dynamic nature of soundscapes. Adding to the complexity, sound can influence an animal's behavior and movement patterns in various ways, such as altering communication space, alerting predators to the presence of prey, and causing avoidance of the sound source. SDMs could be improved by the incorporation of soundscape data and acoustic species detection data. Here, we devise novel methodologies for incorporating acoustic data into SDMs, both at a species level using endangered North Atlantic right whales as a case study and at a community level focusing on richness and diversity, to provide a generalizable framework for ecological inference from these types of models. When parameterized by data from well-designed surveys, relevant predictors, and an appropriately identified model, SDMs can characterize the natural distributions of species and subsequently provide ecological insight and predict a species distribution across a seascape.

Coastal polynyas: Winter oases for subadult southern elephant seals in East Antarctica.

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Antarctic coastal polynyas are regions of persistent open water and are thought to be key bio-physical features within the sea-ice zone. However, their use by the upper trophic levels of ecosystems remains unclear. A unique bio-physical dataset recorded by southern elephant seals reveals that East Antarctic polynyas are a key winter foraging habitat for male seals. During their post-moult trips from Isles Kerguelen to the Antarctic continental shelf, a total of 18 out of 23 seals visited 9 different polynyas, spending on average 25 ± 20% (up to 75%) of their total trip time inside polynyas. Changes in seal foraging and diving behaviours are observed inside polynyas as compared to outside polynyas. Two polynya usages by seals are observed for the

inactive and active polynya phases, pointing to different seasonal peaks in prey abundance. During the active polynya phase, we link seal foraging behaviour to changes in the physical stability of the water-column, which likely impact the seasonal biological dynamics within polynyas.

Manatee chat — a combination of citizen science and deep learning for identification of manatee calls and mastication sounds

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Identification of biological sounds in large acoustic data sets can be difficult and time-consuming. Deep Convolutional Learning Networks have been used for sound identification and classification, but they require a substantial amount of labeled data. Manatee Chat, a citizen-science project currently housed on the Zooniverse platform, allows participants to easily label sound files.

Over 2,000 citizen scientists inspected 9,259 audio files by listening to the sounds and visually examining the spectrogram. Each 10-second file was rated 15 times by different citizen scientists. Three identification categories were used: manatee calls, mastication sounds and nothing — resulting in 138,885 classifications. The obtained Fleiss' Kappa (multi-raters reliability) was 0.48, indicating moderate strength of agreement.

Next, 2,523 sound files that had at least 80% agreement among raters were selected to train and test the Deep Convolutional Neural Network model. The training set included 1,697 labeled spectrograms, and the validation set included 726 labeled spectrograms. The trained model achieved 97% accuracy on a validation set. The model was tested on 100 new spectrograms that were not a part of the testing or validation set and achieved 85% accuracy.

Data augmentation could further improve model accuracy and the ability to generalize. A number of citizen scientists doing the initial data labeling and subsequent training of Deep Convolutional Neural Networks could provide effective and accurate tracking and identification of manatee calls and mastication events in large acoustic data sets.

Fantastic Beasts and Where to Find Them: Modelling the distribution of deep diving cetaceans in the eastern North Atlantic.

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As Governments increasingly seek sources of clean renewable energy, the search is turning increasingly to deeper waters further offshore. These habitats are relatively undisturbed compared to some of the more coastal environments, and as such, conservation of both the habitats and the species that rely on them is a pressing issue. Beaked whales, and other deep diving cetacean species such as sperm whales and pilot whales are some of these species. They are challenging to study at sea due to their long dive times and relatively short periods of time at the surface between dives. This makes them difficult to detect on conventional sightings surveys. As a result, there are typically only very low numbers of detections from large scale surveys resulting in insufficient data to model the spatial distribution of these animals in their offshore habitat. However, combining data collected from many different platforms of opportunity with those from specific cetacean surveys can maximise the data available for analysis, allowing investigations that would not otherwise be possible.

This study combines deep diving cetacean data collected on the SCANS-III, ObSERVE and NASS cetacean surveys with equivalent data collected on more than 30 years of seabird surveys carried out throughout the North Sea and European Atlantic. Data were modelled using GAMs to find the relationships that best explained variability in distribution as a function of a variety of static (e.g. depth, slope) physical (e.g. SST) and biological (e.g. chlorophyll a) oceanographic variables, based on a rigorous model selection framework. Preliminary results highlight the importance of depth and slope to these deep-diving species, emphasising the need for further research as their primary habitat becomes increasingly targetted for exploitation.

Patterns of cranial directional asymmetry among Odontocete species and families

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Bilateral directional asymmetry in odontocete skulls has been described in extant species as well as fossils, with different degrees of intensity. This asymmetric condition has widely been associated with biosonar and communication. This study used 2-dimensional geometric morphometrics to analyse and compare the cranial asymmetry of five odontocete families: Iniidae, Pontoporiidae, Delphinidae, Monodontidae and Phocoenidae. We used photographs of skulls in dorsal aspect from 150 specimens, without stratification by sex or age. Twenty-six homologous anatomical landmarks were selected to allow repeatability and reliability among different taxa. The configuration included landmarks along the central axis of the skull, and paired, corresponding landmarks at each side of the skull. Procrustes ANOVA demonstrated the presence of significant directional asymmetry with a higher variance than fluctuating asymmetry. Principal component analysis of the asymmetric shape component presented a general leftward shift of the dorsal midline in combination with increased dimensions of right-side bones. The first principal component presented torsion of the rostral tip and the brain case to the left side, whereas the nasal bones and the premaxilla shifted to the right. Meanwhile, the second component represented opposite torsions, and also demonstrated greater magnitude in these distortions. Analysis of vectors describing species-specific deviation from symmetry revealed that the patterns of asymmetry were largely similar among species and families. Comparisons of species-specific magnitudes of asymmetry revealed the both monodontids were among the most asymmetric species. *Pontoporia* had the most symmetric skulls, followed by first *Inia* and then phocoenids. Delphinidae were the most diverse family and demonstrated a remarkable spectrum of lower and higher magnitudes of asymmetry, independent of size and the skull shape.

Locating ship strike risk hotspots for fin whale (Balaenoptera physalus) and sperm whale (Physeter catodon) along main shipping lanes in the North-western Mediterranean Sea

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For the two Mediterranean subpopulations, the "vulnerable" fin whale and "endangered" sperm whale, ship strikes with large vessels are one of main causes of decline. For both, the North-western Mediterranean Sea, and especially the Pelagos Sanctuary (PS) is a regular feeding ground crossed by a large amount of shipping lanes intensively used. The mapping of ship strike risk hotspots is an urgent conservation measure tool. A 10years dataset (2009-2018) collected in central PS along 3 North–South and 1 East–West long-distance ferry lanes was used to identify the species-hotspots. Data were collected weekly by MMOs aboard ferries from June to September. Over the 79,048km surveyed, we collected 1'237 sightings of fin whale and 133 sightings of sperm whale (respectively 1'653 and 160 whales). The effort intensity was computed using a buffer around the on-effort transects. The buffer size was defined analysing the distance sampling data obtained specifically for the two species. Similarly, for each species, a buffer was applied around each sighting in order to represent the whale sighting area. Then, the SPUE values were calculated and normalized by lane and by year, to overcome the differences in survey effort among transects. Yearly spatial distribution as well as persistence of risk-hotspots through years have been examined in order to identify priority areas of conservation. For each year, we highlighted at least 1 risk-hotspot per lane (i.e. normalized SPUE > 0.5) and through years, few persistent risk-hotspots. These risk-hotspots are consistent with species habitat preferences but not only; some are surprisingly also in coastal areas, in particular, at the entrance of few main ports. This result establishes priority areas for conservation measures to minimize ship strike risk.

The decrease in the occurrence of cancers in St. Lawrence estuary beluga (Delphinapterus leucas) supports a causal relationship with polycyclic aromatic hydrocarbon exposure.

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Over the last 36 years, we have monitored the causes of death in the endangered population of St. Lawrence beluga (*Delphinapterus leucas*). During this period, cancers have been documented in 18% of the 193 stranded adult beluga (≥8 years old) examined. Direct exposure to sediments containing carcinogenic contaminants, such as Polycyclic Aromatic Hydrocarbons (PAHs), was proposed as the main risk factor to explain this unusual occurrence of cancers. A marked decrease in the reported cancers has been documented over the years in this population: the last case of cancer was diagnosed in 2011, whereas gastrointestinal tract cancers were not documented over the past 14 years. The occurrence of cancers is significantly lower (0% vs 23%; p=0.0012) in adult belugas born after 1976 (n=41) than in those born during or before the period of relatively high industrial PAHs dumping, between 1950 and 1976 (n=152). We calculated a theoretical PAHs exposure index for each examined adult beluga based on their estimated age and historical contamination data for the Saguenay River. The likelihood of an animal being affected by at least one type of cancer significantly increased with the increase of the PAHs exposition index ($p<0.0001$). This relationship was also statistically significant for gastrointestinal tract and mammary gland cancers ($p\leq0.003$). These observations, as well as recently published work on intestinal PAH-DNA adducts in belugas, strongly support the proposed causal relationship between the development of cancers in this population and its exposure to industrial contaminants. Neoplastic conditions seem no longer to be a conservation issue for this population.

Cholangiocarcinoma in a harbour porpoise from the North Sea.

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The harbour porpoise (*Phocoena phocoena*) is the only native cetacean species in the German North and Baltic Seas and classified as least concern in the North Sea, whereas critically endangered in the Baltic Sea. Anthropogenic impacts like fishery, offshore windfarm construction and pollution are its main threats. Persistent organic pollutants (POPs) may impair immune and endocrine systems but also induce tumours known from Saint Lawrence Estuary belugas. Cetaceans rarely display neoplasia. Few cases are described in harbour porpoises, especially in the gastrointestinal and reproductive tracts. Hereby, we report a cholangiocarcinoma as new case. In 2018, a male, adult harbour porpoise with dyspnoea and moderate nutritional status stranded alive and died on Amrum, Germany. In the necropsy, the liver displayed diffuse, whitish, firm, up to 3 cm large nodules and a ventral bile duct cyst, potentially caused by trematodes (*Campula oblonga*), although none were located macroscopically. The abdominal lymph nodes near the aorta showed whitish foci on the cut surface. An infiltrative, poorly differentiated adenocarcinoma was determined histologically, originating from the bile duct epithelium. Infiltrative metastases were located in the abdominal lymph nodes and right adrenal gland. Furthermore, inflammations associated with parasitic infections were detected in the liver, lung, stomach, intestine and right ear. The tumourigenesis is uncertain. Genetic predisposition, pollutants or infectious agents may be responsible. The liver is an important POP metabolising organ and accumulates a higher amount of certain POPs than blubber. PCBs are cancer promotors and immunosuppressors. Chronic bile duct inflammation caused by flukes generates hyperplasia and proliferative epithelium alterations, being potential tumour precursors. Cholangitis, bile duct cysts and trematode infection are described as human cholangiocarcinoma risk factors, which can also be found in harbour porpoises. A connection between the tumours and POPs as well as liver fluke infections in this case needs to be further investigated.

Direct reprograming of dermal fibroblasts derived from Northern elephant seals into muscle cells

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Ex vivo tissue culture is a powerful technique that allows the study of complex cellular mechanisms that are relevant to physiological responses in animals while overcoming the challenges presented

by studying animals that are not tractable. In a primary cell culture system, certain proliferating cells can be functionally reprogrammed into other cell types via overexpression of key genes. Dermal fibroblasts can be reprogramed into muscle progenitor cells (myoblasts), which are often challenging to obtain but offer a unique system to study metabolic responses, by overexpression of the myogenic transcription factor MyoD. We isolated dermal cells from Northern elephant seal (NES) skin samples using enzymatic digestion and propagated them in primary culture. NES dermal cells stained positive for the fibroblast marker Platelet-derived growth factor receptor. Primary NES fibroblasts were amenable to eGFP transfection by both, lipofection and electroporation. Maximal transfection efficiency was achieved using the Neon Electroporation system and corresponded to 55% of living cells. We overexpressed MyoD in NES fibroblasts and conducted antibiotic selection of MyoD-expressing cells with 2 ug/mL puromycin for 3 days. As expected, expression of MyoD was significantly higher (17-fold) in overexpressing cells according to RT-qPCR analysis (t-test $p < 0.05$). We are currently evaluating the capacity of MyoD-expressing dermal fibroblasts to differentiate into muscle fibers and comparing differentiation and metabolic profiles with fibers differentiated from primary NES myoblasts. Establishing differentiated muscle fibers from other mature cell types such as fibroblasts could provide a unique platform to conduct mechanistic studies in marine mammal species where muscle biopsies cannot be obtained from live animals.

The Sea Mammals and Sonar Safety (3S) project: 13 years of Behavioral Response Studies investigating the impact of naval sonar on marine mammals.

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For 13 years the 3S-project (Sea Mammals, Sonar and Safety) has been studying the effects of military sonar on cetaceans in Norwegian waters. We have focused on 6 species' behavioral responses to different sound levels. Currently we are aiming to extend our results using an operational sonar in at-sea experiments, and looking at the effects of higher duty cycle sources (Continuous Active Sonar, CAS). In this paper we will present an overview of key results obtained thus far, emphasizing recent results.

The most striking results we have achieved in the project are:

- Clear indications of behavioral responses to sonar were documented for all species.

- Dose response curves for four different species: killer/long-finned/pilot/sperm/humpback whales, showing large variation in response thresholds

- Type and severity of responses varied significantly across species, and also between individuals of the same species.

- Bottlenose whales (a beaked whale) were demonstrated to be most responsive, with strong responses at large distances (>20km) from the source. Killer whales were (surprisingly) responsive to sonar in some experiments. Sperm and pilot whales were less responsive.

- Frequency specificity of response is not explained by hearing ability

- Ramp up or soft start reduces risk of hearing impairment – but only for responsive animals

- Responses to continuous sonar are similar to responses to pulsed sonar at the same SEL level in sperm whales.

- The nature and severity of behavioral responses to sonar can match the anti-predator response template depending on the studied species and sonar exposure types.

- Herring, an important prey item for many cetaceans (e.g. killer whales), did not respond to naval sonar. Hence, responses like feeding cessation cannot be explained directly by prey movement.

Implications for management and directions for future research will be discussed.

Beyond Maui: Humpback whale occurrence across the Hawaiian archipelago revealed through the prevalence of song.

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The Hawaiian archipelago is the principal breeding ground of north Pacific humpback whales (Megaptera novaeangliae), hosting approximately half of the population during winter and spring months. Historical data suggest that the main Hawaiian Islands (MHI), and specifically the four-island region of Maui-Molokai-Lanai-Kahoolawe, serve as the primary wintering habitat of the Hawaii distinct population segment (DPS) of the north Pacific stock. However, beginning in 2015, commercial operators, researchers, and citizen-science counts began reporting unusually low numbers of whales in the MHI, leading to speculation that whales may be migrating in smaller numbers or possibly using more remote parts of the archipelago. As a result, there is increased need to better understand the occurrence and distribution of humpback whales across the archipelago, including on the banks and atolls of the Northwestern Hawaiian Islands (NWHI), which have remained largely unsurveyed. To address this need, both historical and contemporary data from bottom-moored acoustic recorders deployed throughout the MHI and NWHI were analyzed for the occurrence and abundance of humpback whale song, which is produced by males during the breeding season. The data reveal that humpback whale singing is common throughout the archipelago, including in remote parts of the NWHI. This indicates that nearly the entire Hawaiian archipelago is used as breeding habitat, not only the MHI. However, differences in whale song prevalence among locations suggest that parts of the archipelago are likely used preferentially. In light of these findings, a re-distribution of whales to other parts of the archipelago is at least a plausible explanation for the changes recently observed in the MHI. In addition, the documented presence of whales across more than 1000 nautical miles raises the possibility that whales from the western Pacific DPS may also use parts of the archipelago, which would imply a more complex stock structure than previously assumed.

How to remotely assess body condition on Antillean manatees: The DIY (drone it yourself) alternative.

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Body condition index (BCI) is an important morphometric measure for monitoring the health status of sirenians. The capture and handling of wild manatees enables accurate body measurements but are invasive, expensive and logistically challenging. We tested the use of small drones to remotely collect morphometric data from captive Antillean manatees at Dolphin Discovery facilities in Quintana Roo, Mexico. The manatees (n = 12) were considered healthy at the time of the experiment and were previously measured according to standard protocols to obtain standard length (SL^M) and umbilical girth (UG^M). We conducted 15-min flights (n = 11) with a DJI Phantom 4 Pro drone at altitudes between 10–100 m and obtained 173 minutes of video recordings the manatees. A polystyrene white block (1m x 0.25 m) was placed at water level as a reference object of known size to scale images. We selected 308 images of manatees oriented horizontally near the water's surface and assessed their standard body length (SL^D) and maximum width (MW^D) from the drone images using *ImageJ* software. The umbilical girth was calculated by the formula $UG^D = MW^D \times \pi$. Mean values (± SE) of SL^D and UG^D were obtained for adults (253.8 ± 1.7 cm; 191.3 ±1.5 cm), juveniles (210.6 ± 1.2 cm; 151.5 ± 1.0 cm) and calves (162.2 ± 1.6 cm; 125.2 ± 2.2 cm). No significant differences were found among SL^D and SL^M ($U=54$, $p=0.31$), suggesting that measurements obtained by drones can offer a good

proxy of the 'real' manatee size. The relative error (%) of SL^D was 8.1 ± 3.8% (Mean ± SD). The average of BCI (UG^D/SL^D) was 0.75 ± 0.05 (Mean ± SD). Our results highlight the potential of drones to conduct body assessments of free-ranging manatees in order to monitor the health status of their populations.

Towards a sustainable whale watching in Reunion island in the South-west Indian Ocean: Assessing and mitigating humpback whale (Megaptera novaeangliae) tourism disturbance.

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The whale watching industry has grown rapidly worldwide over the last decade. Reunion Island is no exception to the rule, its coasts attract a growing number of humpback whales (HW) during the austral winter breeding season, few nautical miles away from seaside resorts. This recent industry has raised concerns about the behavioral responses of HW to whale watching (WW) and swim-with whales (SW) disturbances. A responsible observation of cetaceans was recently encouraged through a charter and a label. In 2017, a team "Quietude" was committed to monitor and sensitize whale watchers at sea to ensure compliance with this charter. We assessed WW and SW activities in Reunion Island during three HW breeding seasons from June 2017 to October 2019. Until now, a total of 411 hours was spent collecting data, 105 hours of which occurred with HW behavioral recording. Observed groups were mostly composed of mother/calf pairs spending most of their time resting and nursing. Vessels were present in 85% of sightings with recreative vessels accounting for 68.4% of vessels and SW activities observed in 42% of sightings. General compliance with the charter is high (71.2%) but low with the specific recommendations on SW activities (< 38%). Swimmers were reported on active groups and some agonistic behaviors were revealed, leading to challenging safety issues. Resting along with nursing behaviors of HW were disrupted to a level that raises concern. HW tend avoid vessels and SW encounters, especially when the behaviors of whale watchers were not compliant with the charter. Our results advocate for reinforcing tourism education, management and control with an emphasis on SW activities. This could be efficiently achieved by engaging all stakeholders with the charter concomitant with the permanent team at sea to enhance dissemination of best practices and to sensitize on the sustainable values of implemented regulations.

Factors influencing the duration of implantable satellite tags in humpback (Megaptera novaeangliae) and right whales (Eubalaena spp.).

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Implantable satellite tags have provided new information on movements, migration, distribution and behavior of large whales. These tags are designed to provide long-term tracking and currently remain attached for several weeks to several months. In this study, factor influencing implantable tag duration were evaluated for humpback whales (Megaptera novaeangliae) and right whales (Eubalaena sp.). Data were extracted from published papers and reports or from unpublished tag deployments. Generalized linear mixed-effect models were used to assess whether a series of explanatory variables (sex, tag model, species and deployment location) influenced duration. Non-collinearity was verified between variables using chi-square Test of Independence ($p \leq 0.5$). The results were evaluated considering the most parsimonious model and also the lowest Akaike's Information Criterion (AIC). Mean duration for tags deployed in humpback whales was 33 ± 38.5 days, for the Eubalaena australis mean was 69.1 ± 61.2; for Eubalaena japonica mean was 40.7 ± 15.3 and for Eubalaena glacialis mean was 22.9 ± 13.7. The most supported model indicated that sex and models of trasmitters were the variables to significantly influence the tag duration. The tag model could be influence on the durability due to constantly improving in the attachments of tags to whales to ensure long-term retention. The differences on the attachments must be evaluated. The influence of sex suggests that differences of behavior between males and females is an important factor in the duration of both species. Further analysis should include other factors (e.g., social role) and other species to further understand retention of implantable tags on large whales.

Analysis of plastic bioaccumulation in stranded marine mammals and correlation to diet through stable isotope analysis.

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Plastics are pervasive in marine ecosystems, which can lead to bioaccumulation of those plastics in marine predators. This ingestion of plastics can occur through direct consumption as well as through trophic transfer. While these mechanisms are known to occur, patterns of accumulation across species and geographic areas are only starting to be explored. Marine mammals offer an opportunity to analyze this, as they feed on lower taxa. This study aims to look at plastic bioaccumulation directly through stomach content analysis of newly stranded marine mammals. Carcasses that wash ashore at Año Nuevo state park in Pescadero, Ca will be analyzed for levels of plastic ingestion. While the sample size and species studied will be dependent upon what washes ashore, it is predicted that species of pinnipeds such as the northern elephant seal (Mirounga angustirostris), the stellar sea lion (Eumetopias jubatus) and the California sea lion (Zalophus californianus) will be among the most common as these species haul out in and around Año Nuevo. Through direct observations of plastics in the stomach, the study seeks to correlate the amount and type of plastic to carcass demographics such as species, sex, age class, and size. Plastic analysis will be done by visual inspection of gut content, using the naked eye for macro plastics and microscopy for micro plastics. The other goal of this study is to test for a correlation between the observed plastic accumulation and diet, through stable isotope analysis of pinniped vibrissae. The vibrissae will be analyzed for δ13C (carbon 13 isotope), which will provide an indication as to where in the water column the animal was feeding. While not a direct analysis of diet, if a correlation is found, it could suggest a link between feeding ranges and plastic bioaccumulation, which has not been widely studied

Site use and connectivity of adult female grey seals (Halichoerus grypus) in Wales and the Celtic Sea

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The grey seal (*Halichoerus grypus*) is listed in Annex II of the EU Habitats Directive and is a qualifying feature of three Special Areas of Conservation (SAC) in Wales. Since 1992, Natural Resources Wales and its collaborators have maintained a photographic identification (photo-ID) database, surveying seal breeding and haul-out sites around the Celtic and Irish Seas. Here, we investigated site use and connectivity of female grey seals within the Celtic and Irish Sea database. A total of 2,857 individual females were identified from left heads and 2,789 from right heads (there were few opportunities to link left and right sides) within the computer-aided pattern recognition software *ExtractCompare*. In comparison, pup production in Wales was 1,650 in 2017. Capture histories were generated for uniquely identifiable individuals using a spatially-explicit capture-recapture algorithm. Most recorded individuals were only seen once (77% left heads, 78% right heads). For individuals seen more than once, 12% from left heads and 13% from right heads were recorded twice, and <1% were recorded seven times or more. One individual first identified at Skomer Island was "recaptured" 12 times between 1993 and 2016 at locations around Skomer and Ramsey Island. For individuals seen more than once, transition probabilities were calculated to investigate connections (implied movements) of seals between main locations. The highest transition probability was Bardsey Island:Lleyn Peninsula (0.7) which are both within Lleyn Peninsular and the Sarnau SAC. Transitions occurred between locations within an SAC (e.g. Bardsey:Cardigan Bay, 0.09) and between locations within and outside of SACs (e.g. Bardsey:Anglesey, 0.06). There was a high transition probability (0.5) between the Dee Estuary and Anglesey, but neither of these haul-out sites are included in a SAC. This shows that female grey seals move throughout the Celtic and Irish Seas and are not limited to the site at which they breed.

Metabolic rate determination in wild dugongs

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Little is known about the metabolism, energetics, and food requirements of dugongs (*Dugong dugon*). The related manatees have low metabolic

rates (only 25-30% of predicted values for large mammals) and based on phylogeny, it has been assumed that dugongs have comparably low rates. However, measured rates of water turnover have indirectly suggested that dugongs may either have relatively high metabolic rates or that dugongs practise mariposia (voluntary drinking of seawater). This project, conducted in Australia in the first week of austral spring, measured oxygen consumption in a total of five resting non-gravid adult dugongs held at thermal neutrality in a metabolism chamber. Oxygen consumption expressed in terms of absolute body mass was converted to resting metabolic rate (RMR), and energy expenditure at rest was also calculated. Mean O_2 consumption ranged from 2.12 to 2.9 mL $kg^{-1}min^{-1}$, RMR from 29,943 to 40,799 kJ day^{-1}, and energy expenditure at rest from 0.81 to 0.99 W kg^{-1}. RMRs for these five dugongs were higher than those reported for the related West Indian manatee, but are comparable to rates for similarly-sized marine and terrestrial mammals. We suggest that the higher RMR of dugongs compared to manatees may explain discrepancies between their behavior, growth and reproductive rates. A higher rate of metabolism may account for dugongs' more active pelagic habits and may help clarify why growth and reproduction are slow. Whilst metabolism and energy expenditure are relatively high, grazing on a low-nutrient, low-energy seagrass diet means that dugongs use a high proportion of the energy extracted from their diet to power metabolism, and thus allocate a lower proportion to growth and reproduction. Future work will explore the effect of seasonal water temperatures on RMR of dugongs.

Let it grow: Ontogenetic growth of the minke whale skull and implications for the teeth-to-baleen transition in Mysticeti (Cetacea).

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Baleen whales (Mysticeti) have an extraordinary fossil record documenting the transition from toothed raptorial taxa to modern species that employ baleen plates for filter feeding. However, while adults bear baleen plates, tooth germs still develop unerupted *in utero*. Ontogenetic data, combined with present knowledge of modern and fossil mysticete skull anatomy, provide a better understanding of the mechanisms of this unique macroevolutionary transition. Though, currently little information is available on prenatal development of baleen whales, especially regarding tooth resorption and baleen development. Here, I present the first comprehensive description of the ontogenetic sequence of minke whales (*Balaenoptera acutorostrata* and *B. bonaerensis*), focused on the skull internal anatomy and tooth germ development, resorption, and baleen growth. The anatomy was analyzed using traditional and iodine-enhanced computed tomography (CT and diceCT) scanning of 10 specimens of both minke whale species, spanning from the earliest fetal stages to full term. Using these non-invasive methods allowed reconstruction of virtual 3D models of the specimens and geometric morphometric (GM) analyses, in addition to providing traditional qualitative descriptions. Tooth germs appear to resorb completely just before eruption of the of the baleen from the gums, and they are still present for a brief period along with baleen rudiments. GM analyses show that the rostrum progressively grows in length relative to the braincase, and that the supraoccipital shield elongates anteriorly during gestation. Both changes contribute to a defining feature of cetaceans, telescoped skull. This information aid in the interpretation of fossil morphologies that exhibit intermediate traits between modern filter feeders and raptorial feeders, but caution is needed when comparing prenatal extant specimens to adult fossils. This new data greatly enhances our understanding of baleen whale ontogeny and of the role of developmental transformation in the evolution of mysticetes.

Sea otter (Enhydra lutris) seasonal diet composition in southern Southeast Alaska

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Until translocation efforts in the 1960s, sea otters (*Enhydra lutris*) were absent from Southeast Alaska due to extirpation from the fur trade in the 18th and 19th centuries. About 400 sea otters were reintroduced to six Southeast Alaska locations with consistent population growth to date. Previous foraging studies throughout the sea otter range have shown that sea otters will reduce invertebrate prey biomass when recolonizing an area. By quantifying sea otter diets and caloric intake according to recolonization patterns, we can better understand the ecosystem impacts of sea otter population increase and range expansion. We hypothesized that sea otter diet will vary according to age, reproductive class, seasonality, and time since recolonization. Foraging data were collected

around Prince of Wales Island to determine diet composition during the summer. Sea otter vibrissae were obtained from subsistence hunters to assess seasonal changes in sea otter diets by using bulk stable isotope analysis. Sea otter prey items were collected in three seasons (spring, summer, and winter) to measure caloric value and stable isotopes of carbon ($d^{13}C$) and nitrogen ($d^{15}N$). Overall population-level diet composition consisted of 69% of the biomass derived from clams, with butter clams (*Saxidomus gigantea*) as the main clam species in this mixed-bottom habitat. This study aids in the future management of shellfisheries, subsistence hunting, and co-management of a protected species by providing quantitative diet composition data for stakeholders. This work is a part of a large-scale project examining how the recovery of sea otters structures nearshore marine ecosystems, provides ecosystem services and affects community sustainability.

After 12 years of knowledge gap: New data on franciscana bycatch in the artisanal gillnet of Torres and Passo de Torres, southern Brazil, assessed through onboard observers.

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The franciscana (Pontoporia blainvillei) is endemic of coastal waters from Brazil (18°25'S) to Argentina (42°10'S). The species is considered the most threatened cetacean in the western South Atlantic due to high bycatch mortality in gillnets fisheries. Four Franciscana Management Areas (FMAs) are recognized. Bycatch levels in FMA-III (Brazil/27º37'S- Uruguay/34º34'S) are the highest among all FMAs, but since the middle 2000s fishery monitoring have been interrupted. This study reports preliminary results of resuming efforts to estimate franciscana bycatch in artisanal gillnets fisheries with onboard observers at Torres/Passo de Torres, southern Brazil (29°19'S/49°42'W, north FMA-III). From June/2018 to April/2019, 27 one-day fishing trips of two vessels were accompanied by observers. Location of fishing grounds, gear type, target species, fishing effort, and the number of franciscanas incidentally caught were recorded for each fishing trip. Fishing occurred within an area of 164km^2, ranging in depths of 15-28m. The drift (surface) gillnets used had (mean±SD) 818±151m in length, 11m in height and mesh sizes of 8.2±0.25cm. A total of 50 surface sets were accompanied with soaking time of 0.7±0.24h, resulting in the capture of 1,106kg of target species (*Pomatomus saltatrix*) and none franciscana. Bottom trammel nets used had 3,728±1,265m in length, 1.95±0.09m in height and mesh sizes of 20±0.0cm (inner panel) and 60±0.0cm (outer panels). A total of 21 bottom sets were accompanied with soaking time of 27.5±9.7h, resulting in 1,234kg of target species (mainly *Micropogonias furnieri* and *Paralichthys orbignyanus*) and six franciscanas by-caught (Catch-per-unit-effort [CPUE] = 0.000003franciscanas/m/h). Our preliminary results indicate higher CPUE values for franciscanas in bottom gillnets than those reported for the same area in the 2000s (CPUE=0.000002franciscanas/m/h). Continuity of the fishery monitoring is essential to estimate annual mortality and assess its seasonality, as well as to understand the effects of the current bycatch on the long-term viability of franciscanas.

Spatial haul-out dynamics of three sympatric Alaskan pinnipeds

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Many pinniped species haul out in terrestrial habitats to enact critical behaviors and life history events. High-resolution remote sensing reveals how such behaviors interface with a physical environment to structure pinniped haul-outs. In the Pribilof Islands of Alaska, three pinniped species regularly use terrestrial habitats to haul out; these haul-outs can overlap in time and they describe unique, though not necessarily discontiguous spatial habitat associations. In October 2018, a survey using unoccupied aircraft systems (UASs) mapped simultaneous, sympatric haul-outs of three species on Otter Island: the northern fur seal (*Callorhinus ursinus*), the harbor seal (*Phoca vitulina*) and the Steller sea lion (*Eumetopias*

jubatus). A synoptic dual-UAS flight survey captured simultaneous visible-light and thermal imagery of these haul-outs. Photogrammetric image processing with Pix4D software yielded high-resolution othomosaics in visible light (2.6 cm/pixel resolution) and thermal infrared (17 cm/pixel resolution), and derived a digital surface model (2.6 cm/pixel resolution) of the study region. Spatial analyses of these products reveal species-specific behavioral affinities toward distinct physical environments and between animals. Conspecific clustering is discernible in preliminary products and is quantifiable as spatial autocorrelation among pinniped locations, but it is ambiguous whether this reflects conspecific attraction or convergence on limited suitable terrestrial habitat. Here we apply fine-scale habitat suitability modeling to describe, for each species, spatial autocorrelation of haul-out locations amid suitability models of landcover type and surface topography. The presence (or absence) of alternative but unoccupied habitats for a given species discounts (or fails to discount) the hypothesis that clustering reflects a convergence on limited suitable habitat. Such insights into haul-out structural dynamics can inform future monitoring, research and conservation efforts in the Pribilof Islands and other terrestrial pinniped habitats.

Whose pregnant? Parsing out postpartum and parturient Pacific walruses using endocrine profiles.

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The reproductive cycle of female Pacific walruses (*Odobenus rosmarus divergens*) is characterized by breeding in winter, an embryonic diapause from conception until summer and parturition the following spring. Like other pinnipeds, female walruses likely undergo a postpartum estrus, but the function for this is unknown as males are thought to be infertile outside of the breeding window. In this study we assessed the reproductive statuses of female walruses categorized as postpartum, embryonic diapause, full-term pregnant and unbred. Ovarian tissues and reproductive status were provided by Alaska Native hunters from animals taken in Alaska in May of 2011, 2015 and 2016. Progesterone was measured using enzyme immunoassays and total estrogen concentrations were determined using radioimmunoassays in corpora lutea (CL) of ovaries. For progesterone, CL of postpartum females (n=11) had the lowest concentrations (77.31 ± 58.21 ng/g) whereas CL from unbred females (not pregnant or postpartum) (n=3) had the highest progesterone concentrations (2170.01 ± 246.29 ng/g). One CL was present from a female known to be near full-term pregnancy (62.92 ng/g), as well as one CL from a female known to be in embryonic diapause (108.48 ng/g). For total estrogens, CL from postpartum females had the lowest concentrations (n=8; 15.38 ± 10.17 ng/g). Total estrogens of CL were similar among females that were unbred (n=2; 693.19 ± 467.30), full-term pregnant (n=1; 313.58 ng/g), and in embryonic diapause (n=1; 551.14 ng/g). In this study neither CL progesterone nor estrogen profiles alone were able to differentiate between states of pregnancy in female walruses, with such low sample sizes. To our knowledge, this is the first time that these reproductive hormones have been measured in ovarian tissues for this species.

Reference intervals for traditional and novel physiological biomarkers for healthy common bottlenose dolphins, Indo-Pacific bottlenose dolphins, Pacific white-sided dolphins, and beluga whales.

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Physiological reference intervals are useful when assessing the health status of individual animals. Few zoos or aquariums care for enough cetaceans within their facility to develop functional reference intervals given high inter-individual variability in physiological biomarkers in cetaceans. Further, previously published intervals are limited in their functionality as differing sample collection procedures, analysis methods and inter-laboratory variation render results not directly comparable. To develop functional reference intervals for traditional and novel physiological biomarkers of welfare applicable across facilities, data were collated from cetaceans housed at 43 locations in seven countries. Blood and fecal samples were collected from common bottlenose dolphins (*Tursiops truncatus*), Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), and beluga whales (*Delphinapterus leucus*). Samples collected from clinically healthy animals between July 2018 and March 2019 and analyzed with respect to species, age, sex, pregnancy (females) and month of the year. Reference intervals were generated for 40 hematologic, serum, and plasma biochemical variables, three hormone biomarkers, and one antibody. After establishing reference

intervals for the physiological parameters, intervals were made available in the new iOS mobile software applications, ZooPhysioTrak. Reference intervals in ZooPhysioTrak represent zoo and aquarium cetaceans at the population-level and serve as a frame of reference for future development of community-wide health protocols. For the species with smaller sample sizes, prior baseline physiological biomarker values are extremely limited and our results establish a protocol for collecting comparable samples in the future. ZooPhysioTrak will enable animal care and veterinary staff to enhance clinical care by quickly accessing the expected intervals for a given physiological biomarker on an individual level.

Combining multiple surveys increases precision and provides more reliable mapping of marine mammals distribution.

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Species distribution is a key indicator to inform conservation status of marine mammals, cetaceans in particular, and to predict possibly problematic interactions with human activities. However, the distribution of cetaceans is difficult to assess because they are highly mobile species occurring at low densities and across wide areas.

Here, we propose a formal statistical framework to combine multiple cetacean surveys to overcome these issues. We illustrate our approach considering two aerial and at-sea monitoring programs to estimate the distribution of bottlenose dolphins (*Tursiops truncatus*) in the North-Western Mediterranean Sea. Aerial surveys were designed to monitor marine megafauna across 24,624 km of line-transect over coastal and pelagic North-Western Mediterranean (including the Pelagos Sanctuary). At-sea photo-identification was carried out across 21,646 km of transects performed over the French continental shelf (including Gulf of Lion and Corsica). We modeled the proportion of area used by bottlenose dolphins using occupancy models to account for imperfect and heterogeneous detection between the two surveys. We also considered occupancy models with a single visit per spatial sampling unit.

We found that combining the two monitoring programs greatly improved the precision estimates of the proportion of area used. Also, considering the two surveys jointly in the analysis provided a much better coverage of the ecological gradient, which in turn translated in a more representative map of the proportion of area used by bottlenose dolphins. Last, single-visit occupancy models produced similar estimates to occupancy models with repeated visits, which opens the perspective for a better optimization of the sampling effort.

Overall, our approach allows making the best of marine mammals monitoring programs by borrowing strength of the different surveys (aerial and at-sea) for a reliable assessment of species distribution.

Movements and diving behaviour of Ross Sea Killer Whale (Orcinus orca), along the Ross Sea Region MPA, Antarctica

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The Ross Sea Killer Whale is a fish-eating ecotype (type - C) regularly occurring around pack ice in the Ross Sea, Antarctica. Increasing knowledge on this ecotype's foraging habitats and movement patterns is listed amongst the research priorities recommended under the framework of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). In Terra Nova Bay (TNB) during the austral summer 2015 ten type - C killer whales were equipped with Smart Position Only (SPOT) and depth-recording satellite transmitters (SPLASH) in the Low Impact Minimally Percutaneous External-electronic Transmitters (LIMPET) configuration. Hierarchical switching state-space models (hSSSM) were applied to Argos satellite tracking data to characterize the horizontal behaviour of tagged whales. The behaviour log from SPLASH transmitters returned the maximum depth reached in each recorded dive as well as the dive durations and surface intervals between dives. Tags transmitted on the whales for 19 - 44 d (mean=28.6 d; SD=8.79). Overall, 8,803 Argos locations were available to fit the hSSSM. The Bayesian state-space model revealed discrete, largely non-overlapping Areas of Restricted Search (ARS) along the coast line, as well as transit behaviour in the open ocean outside Antarctic

waters, with no evidence of foraging activity. ARS behaviour infered by the hSSSM matched the pattern of deeper dives, which were typically to depths in excess of 150 m and reached a maximum value of 452 m, thus indicating possible feeding grounds along the Ross Sea coast. Considering the recent institution of the Ross Sea Region Marine Protected Area (RSR MPA), these findings might well contribute to finalizing the research and monitoring programme required by the MPA and furthering conservation measures in the exiting Antarctic Special Protected Area (ASPA).

Tool use increases foraging success in southern sea otters.

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Tool use is a behavioral innovation that allows individuals to obtain otherwise inaccessible food resources including novel prey items. Although researchers have investigated variation in tool use between sea otter populations, they do not elucidate how variation in tool use frequency contributes to differences in foraging success (both biomechanically and energetically) and fitness between individuals. Along the central California coast, southern sea otters (*Enhydra lutris nereis*) exhibit individual dietary specialization and variation in percussion tool use frequency; while some individuals use rocks and shells as anvils or hammers to break open hard-shelled prey, others do not yet still feed on hard-shelled prey. Although recent work revealed that an individual's diet is the best predictor of an individual otter's tool use frequency, little is known about how variation in tool use frequency contributes to differences in prey acquisition, caloric income, and fitness between individual otters. In this study, we tested hypotheses that individual otters with different tool use frequency will vary in their (1) consumption of hard prey items, (2) acquisition of calories, and (3) tooth damage. We analyzed foraging data from 197 tagged individual otters and quantified the fracture forces and caloric energy of different prey items across their respective size classes. We used Bayesian generalized linear mixed effect models to examine each of our hypotheses. Our preliminary results suggest that individuals with greater tool use frequency feed on relatively harder prey items and obtain an increase in caloric income. Increases in tool use frequency, however, do not result in a reduction in tooth damage; rather, age, irrespective of tool use, is the best predictor of tooth damage. These findings suggest that individuals that frequent tool users exhibit greater foraging success by gaining access to relatively harder prey, resulting in greater caloric intake.

Significant improvement of habitat-based distribution models for cetaceans in atlantic canada facilitated by a novel amalgamation of biotic and abiotic data

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Recent cetacean modelling efforts in Atlantic Canada have employed MaxEnt models, with relatively few abiotic inputs and using chlorophyll α concentration persistance and magnitude as a proxy for prey for all species. For apex predators like the killer whale the use of chlorophyll is a poor prey substitute, and the MaxEnt approach itself relies on several subjective choices by the modeller. DFO has spent more than six years cataloguing a variety of georeferenced data strata, including abiotic (such as BPI, distance to shelf edge, dynamic oceanographic features) and biotic variables (such as distribution of higher trophic level forage fish and seabirds with diets similar to the cetaceans of interest). In addition, DFO has conducted recent broad-scale cetacean surveys and continues to expand its autonomous acoustic monitoring programme.

In this study we used habitat-based distribution models to integrate these data for a varied niche spectrum of small and large cetaceans. We then used the survey and monitoring data to assess the performance of the models with several approaches (such as binomial testing).

These models performed better than previous MaxEnt-based assessments when challenged with the systematic survey/acoustic data. With their richer range of data inputs, the improved habitat models will better predict where cetaceans in Atlantic Canada might occur in

response to climate-related prey changes. Moreover, they will allow researchers to implement superior monitoring in the future by focussing on areas with a higher probability that species of interest will be present.

Atlas, frequency and pathology of skin lesions in beluga whales (Delphinapterus leucas) from the St. Lawrence estuary, Quebec, Canada.

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Our knowledge on the diversity, frequency, and causes of skin lesions in free-ranging belugas (*Delphinapterus leucas*) is limited. The objectives of this study were 1) to establish a classification system of skin lesions in belugas from the St. Lawrence Estuary based on macroscopic appearance, 2) to estimate the frequency of skin lesions categories (SLC) observed during photographic surveys of this population and 3) to explore the causes of SLC in this population. A list of 18 SLC was suggested and their frequency on St. Lawrence Estuary belugas was assessed using 26,020 photographs, representing 5,388 randomly selected individual sightings, collected from 2003 to 2014 as part of a photo-identification program. Images of individual sightings of sufficient quality were screened by one observer for the presence of SLC. In individual sightings of gray and white belugas, “rake marks” (gray: 77.2%; white: 69.5%), “single linear scars” (gray: 55.1%; white: 55.0%), and “circular depressions” (gray: 39.9%; white: 34.9%) were most often observed, while “single linear fissures” (21.9%), “single linear scars” (19.2%) and “ulcer-like lesions” (17.1%) were most frequent in individual sightings of neonates. In addition, cutaneous lesions from 111 St. Lawrence Estuary belugas stranded between 1983 and 2017 were characterized microscopically. Needle-like foreign bodies were found within some “pinhole erosions” and a gamma-herpesvirus was detected by PCR in a wound. The potential cause and significance of most SLC observed in this study remain largely undetermined. “Yellow patches”, “circular depressions” and “map depressions” may be partly associated with seasonal molting in gray and white belugas. Postnatal molting could partly account for “ulcer-like lesions” and “single linear fissures” in neonates. This is the first study which investigates skin conditions in belugas in the St. Lawrence Estuary.

Assessing pinniped response to diadromous fish conservation efforts in the Penobscot River estuary

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Following historical overexploitation across the North Atlantic, seal populations have increased in the Gulf of Maine since federal legislation aimed at their conservation was passed in 1972. More recently, reports of seals in the Penobscot River Estuary have increased. The Penobscot River Estuary in Maine, USA is the site of almost a decade of collaborative diadromous fish conservation and habitat recovery efforts. Successful conservation efforts have resulted in the growth of some populations of forage fish that use the river and estuary as spawning habitat. The objectives of this research are to evaluate trends in abundance and distribution of seals in the Penobscot River and assess their overlap with changes in the biomass of diadromous fish. A feasibility assessment of using photo-identification techniques to study individual patterns of seal spatial distribution and seasonal use will also be presented. To achieve these objectives, pinniped abundance and distribution data will be compared to hydroacoustic fish density data, both of which have been collected since 2012. Between 2012-2018, 11-18 surveys were conducted each year. Following an initial drop from peak observations in 2013 (47.7 sightings/survey), seal sightings in the river have generally increased since 2014. Seal sightings are typically highest from mid-April through May, partially overlapping with the peaks of several diadromous fish runs. This study provides an opportunity to assess pinniped ecology in a recovering system. This research will also evaluate the impacts of conservation efforts on predator-prey dynamics, which could inform future management decisions on how to best reconcile the competing objectives of marine mammal protection and fish restoration. This insight could be applicable to other systems involving protected species, as well as systems that are recovering from habitat loss and overexploitation.

Sexually diagnostic morphometrics enable photogrammetric monitoring of size structure and group composition for common dolphins

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Common dolphins are an abundant upper trophic level predator in the California current, and as such can constitute a key indicator of environmental change. However, their abundance, large school sizes and pelagic ranges make individual re-identifications impossible. Instead, we are developing aerial photogrammetry measurements of length and body proportions as a tool for determining age and sex composition of groups. To validate this approach, we examined morphometrics of stranded and by-caught short-beaked (*Delphinus delphis*, n =359) and long-beaked common dolphins (*Delphinus capensis*, n=259) from the California current. Adult males were significantly longer for both species (average 186cm vs 178cm for *D. delphis* and 219cm vs 207cm for *D. capensis*). This sexual dimorphism was not significant in the measurement from snout to anterior insertion of the dorsal fin, but driven mostly by males having significantly longer tails: the measurement from the anterior insertion of the dorsal fin to the fluke notch as on average 7cm longer for males of *D. delphis* (representing 87% of the average length dimorphism) and 10cm longer for males of *D. capensis* (81%). We demonstrate how these sexually diagnostic morphometrics can be used in aerial photogrammetry studies to determine if adult males are present within schools, particularly when high-resolution images are available from low-altitude drone flights. This information is being used to examine ecological covariates for common dolphin group composition and size structure, and to investigate underlying sensitivities of certain group compositions to sonar, as part of controlled exposure experiments.

Applying the CAF-mapping algorithms to marine bioacoustics.

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This presentation will discuss the adaptation of the Cross Ambiguity Function Mapping (CAF Map) algorithm and adaptations developed to use it in acoustics. The CAF Map algorithm provides a useful means of generating a geographic visualization of acoustic data when the acoustic sources are moving. It can be used to develop tracks of acoustic energy without first detecting and classifying the signal or used as a temporal/spatial filter to detect specific types of target movement. The algorithm is also able to provide discrimination between multiple signals when they are broadcasting in a partially synchronized manner. This may make the algorithm useful to detect, visualize, and track multiple marine mammal sources and observe acoustic interactions. Application to multiple sound sources will be presented, including possible blue whale (*Balaenoptera musculus*), right whales (*Eubalaena australis*) data and simulated humpback whale (*Megaptera novaeangliae*) calls.

Reproductive parameters of Indo-pacific humpback dolphin (Sousa chinensis taiwanensis) in Taiwan

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Female reproductive parameters are important for understanding population dynamics and helpful for conserving small or declined population, i.e., the Indo-Pacific humpback dolphins (*Sousa chinensis taiwanensis*) population in Taiwan. In total of 25 breeding females and 33 different mother-calf pairs were identified from 359,452 photographs, which collected though 1056 boat surveys from Miaoli to Tainan county between 2008 to 2017. Overall, female dolphins gave birth all year around, and higher in spring and summer (May to September). The average crude birth rate was 0.032 with calving interval 5.01 years. Comparing the calf survivorship from age 1 to age 3, both calf survival rates and age-specific survival rates decreased in recent years. In average 1.2 independent calves were recruited into population each year, indicating the population were in slow growth rate. Our results indicate an emergency sign for this small population and active conservation management are immediately requested.

How do noise measurements made with seismic streamers compare to those made using marine autonomous recording units (ARUs)?

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Measuring the source levels of anthropogenically produced underwater noise and its subsequent propagation is often a pre-requisite for geophysical surveys or marine construction projects, such as wind farms. Regulators rely upon these source level measurements to ensure mitigation zones for marine mammals are adequate, to keep track of incidental harassment of animals throughout a project's lifespan, and to confirm the accuracy of predictive models used during the planning stages. However, for optimal recordings to be made, additional personnel and specialist equipment are required including at times the inclusion of an additional vessel. Along with delays to the start of a project, this can add significantly to a project's cost and carbon footprint, and to the cumulative sound exposure levels from having an additional vessel on site.

On many geophysical surveys a seismic streamer will be towed behind the vessel. It will be made up of many hydrophones and often exceed a length of 10 km. This has been proposed as a method to measure the source level and propagation loss *in situ* without use of additional equipment, staff, or vessels. In this study we compared the recordings from seabed moored ARUs to those taken using a single seismic streamer. Using a range of predictive models, we aimed to ascertain if the highest quality recordings could be obtained using the streamer method as opposed to the increased investment needed using ARUs.

Killer whale (Orcinus orca) dive behaviour in the eastern Canadian Arctic

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Climate-mediated decreases in summer sea ice have provided killer whales (Orcinus orca) longer access to a more extensive open-water season in the Canadian Arctic. Recent findings have suggested that killer whale occurrence in the Canadian Arctic is increasing, and photographic capture-mark-recapture studies have indicated that ~93 individuals visit the Canadian Arctic's Lancaster Sound ecoregion seasonally. According to local Inuit knowledge, killer whales prey on narwhal (Monodon monoceros) and energetic modelling indicates that this predation may have population-level effects; this is unfavourable for Inuit communities who rely on narwhal for sustenance. However, stable isotope studies and analysis of tooth wear have suggested that killer whales may subsidize their energetic requirements with Greenland sharks (Somniosus microcephalus), lessening the consumptive effects on narwhal accompanying increases in killer whale occurrence. The objectives of this study, which is the first to characterize killer whale dive behaviour in the Canadian Arctic, were to use satellite transmitters to better understand killer whale vertical habitat-use, and in particular, to investigate if killer whales are diving to the seafloor, which would support predation on benthic Greenland sharks. In September 2018, a multi-sensor satellite transmitter, which recorded depth at 75 s intervals, was surface-mounted on the dorsal fin of an adult male killer whale near Pond Inlet, Nunavut. During the ten-day deployment, the killer whale's maximum-recorded depth was 352m, although comparison with the region's bathymetry indicated that none of the animal's dives were benthic. While this suggests that feeding on Greenland sharks is unlikely, deep dives (>50m) occurred almost exclusively at night, which may represent the pursuit of pelagic marine fishes undergoing a diurnal vertical migration. An improved understanding of killer whale dive behaviour and possible feeding on Greenland sharks is necessary to assess the effects of predation on culturally, economically, and ecologically valuable marine mammals in the Canadian Arctic.

Reduced cytokine expression and lymphocyte proliferative capacity in diseased harbor porpoises (Phocoena phocoena) – biomarkers for health assessment in wildlife cetaceans

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Harbor porpoises are the only reproducing cetacean species in the North and Baltic Seas and exposed to anthropogenic influences including acoustic stress and environmental contaminants. Organochlorine compounds can have detrimental effects on the

health and physiology of odontocetes and recent studies show that the effects of PCB pollution continue to affect cetaceans in European waters.

In order to evaluate immune responses in healthy and diseased harbor porpoise cells, lymphocyte proliferation assays and cytokine expression together with toxicological analyses were performed in stranded and bycaught harbor porpoises as well as in animals kept in permanent human care. EDTA blood samples were taken from the epidural vein of 9 porpoises in human care, 11 free-ranging animals, and 4 stranded harbor porpoises found diseased. Lymphocyte proliferation assays were performed and blood contaminant levels measured. Immuno-relevant cell mediators (cytokines TGF-β & TNF-α) were analysed by real time RT-qPCR.

PCB concentrations were highest in the investigated harbor porpoise blood samples, followed by DDE and DDT concentrations. All compounds were correlated, indicating co-accumulation of investigated xenobiotics. Severely diseased harbor porpoises showed a reduced proliferative capacity of peripheral blood lymphocytes together with diminished transcription of transforming growth factor- β and tumor necrosis factor- α compared to healthy controls. mRNA expression levels were significantly higher in porpoises from human care compared to bycaught ($p=0.004$) and stranded animals. In addition bycaught animals showed significantly higher expression levels than stranded animals. Correlation analyses between lymphocyte proliferation data and cytokine mRNA levels revealed that both TGF-β ($p=0.028$; $r_s=0.448$) and TNF-α levels ($p=0.038$; $rs=0.0425$) significantly correlate with ConA-induced lymphocyte proliferation. Results reveal an impaired function of peripheral blood leukocytes in severely diseased harbor porpoises, indicating immune exhaustion and increased disease susceptibility. The development of novel approaches in marine mammal immunology will help to better understand anthropogenic impacts upon cetaceans in the future.

Detection of the distribution of the Yangtze finless porpoises between the mainstream of the Yangtze River and Poyang Lake via passive acoustic monitoring

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As the confluence of the mainstream of Yangtze River and Poyang Lake, the mouth area of Poyang Lake is a significant place reflecting the present status of the dynamic communication and possibly-existing isolation of the Yangtze finless porpoises (*Neophocaena asiaeorientalis asiaeorientalis*) between the River and the Lake. However, there is lack of elaborate information of the distribution patterns of the YFP in the area and impacts from anthropogenic activities, which is urgently needed for informing better conservation actions. In this research, a monthly and appropriately space-extended monitoring of the YFP population in the area has been carried out for the last whole year. Passive acoustic monitoring methods deployed on a moving platform—with two compact self-contained underwater sound recorders towed in tandem behind a boat on one rope, are used to detect the acoustic signals of the YFP. In the meantime, the ship courses were recorded by a GPS to acquire the distribution patterns of the YFP in the study area. 12-month data have been collected and a custom-made YFP acoustic signals detecting program based on MATLAB 2014a has been developed to obtain the time and frequency of the signals. Combined with the data of GPS, 12 pictures of the distribution patterns of YFP for each month in a whole year would be presented. In the next phase, the influence of the water level, shipping as well as two transcurrent bridges near the mouth area would be taken into consideration and analyzed with the distribution of YFP. We expect to get knowledge of and also present at the conference the temporal and spatial variation of the distribution of YFP during the experiment and the impacts of possibly related factors, through which we could have better understanding of the population status and inform better conservation initiatives for the Yangtze finless porpoises.

Diel and seasonal variation in feeding calls of humpback whales in the Kitimat fjord system, BC, Canada.

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Humpback whales Megaptera novaeangliae, known for their songs, produce other sounds on their feeding grounds, whose functions are not fully understood. In South-East Alaska and Northern British Columbia, Canada, the production of a series of 'feeding calls' are associated with bubble-net feeding, a cooperative and coordinated feeding strategy where a group of humpback

whales feed on a prey school corralled by a spiral of bubbles. These call sequences can last more than one minute and comprise single calls that are mainly tonal in their frequency and are centered around 500 Hz. In the present study the diel and seasonal production of feeding calls was investigated for a population of humpback whales in the Kitimat fjord system, British Columbia, Western Canada. Continuous recordings were analysed from May to October 2015 and the occurrence and rate of the calls was recorded for every hour and analysed using GEE and GAM models. Calls were recorded in all months with very few calls recorded in May and a peak in calls recorded in July. Feeding calls were recorded only during daylight hours from May to July and also during night-time from August to October. The intensity of the calls was greater during daylight hours than night, when it was absent or low. The consistent presence of calls from June to October suggests this feeding strategy is an important component for the ecology of the species and the strong diurnal component strengthens the hypothesis that whales, aided by sound as an additional corralling tool, rely heavily on sight for prey detection. Annual variations in the patterns of vocalizations when using this bubble-net prey capture strategy could be used to provide further insights into the ecology of this species and the status of the ecosystem and provide insights into the culture of this species.

Stressed and slim or relaxed and chubby? A simultaneous assessment of gray whale body condition and hormone variability.

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Linking disturbance events with long-term or population level impacts on cetacean populations is challenging. Cetacean body condition and hormone variability mayindicatephysiological responses to natural and anthropogenic stress events. Feasible application of these metrics to measure and monitor cetacean health requires a robust understanding of how these values vary over time, by demographics, and in relation to each other. We undertook a non-invasive study on gray whale foraging along the Oregon coast (USA) to simultaneously evaluate fecal hormone variability and body condition assessed through drone photogrammetry. We also gathered remote sensing data to explore associations between oceanography and body condition. We identified 171 individuals between June and October 2016-2018, from which we collected 164 fecal samples, and conducted 289 drone overflights to collect images for photogrammetric assessments. Immunoassays were performed for progesterone, testosterone, cortisol and thyroid (T3) hormone quantificationin the fecal samples. Hormone validations were also conducted. We observed (1) improvement in Body Area Index (BAI: body condition indicator) over time, at population and individual levels, indicating energetic gain over a feeding season, (2) BAI variation according to demographics, where calves and pregnant individuals displayed higher BAIs, followed by resting females, mature males and, finally, lactating females, (3) higher population BAIs in 2016, correlated tolower sea surface temperature and higher upwelling indices, (4) high hormone level variability (cortisol: 0.078-70.221 $ng.g^{-1}$; progesterone: 0.008-609.106 ng.g-^{1}; testosterone: 0.004-1478.041 $ng.g^{-1}$; T3: 0.039-1592.125 $ng.g^{-1}$), and (4) pregnancy detection through body condition and hormonal assessments. Associations between BAI and hormone variability are also being explored. This is the first study to simultaneously explore the variation in hormone levels and body condition relative to demographics and environmental conditions for any cetacean. Hence, results from our gray whale study system will inform multiple management efforts regarding cetacean physiological health in response to human disturbances.

The IWC at 75 years: Evolving with the challenges.

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The International Whaling Commission (IWC) is one of the world's oldest environmental organizations (est. 1946). The Convention's objective remains to *'provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.'* This vital post-war mandate to ensure food supply has evolved in response to its ever-

changing global context. Today's IWC addresses a growing number of population-level threats from activities other than direct harvest, reflecting how the world has changed over the lifespan of the IWC with a tripling of global human population (2.5 to 8 billion) and extensive environmental impacts of industrialization. While some cetaceans have made remarkable progress and even recovery (eastern North Pacific gray whales) due in large part to the 1986 commercial whaling moratorium, the IWC now faces considerable, complex obstacles in making progress on these emerging sources of population decline, as evidenced in a recent extinction (baiji) and another on the brink (vaquita). The IWC has stepped up to these challenges through scientific research and more recently through engagement in design and implementation of monitoring and mitigation. The globally recognized science and stewardship programs of the IWC provide evidence of the impacts of these new threats and options for action, including: bycatch and entanglement in active and ghost fishing gear (killing over 300,000 cetaceans each year); underwater noise, marine debris and other habitat pollutants; and climate change and its impact on range, feeding, and reproductive activities. The IWC's work program now features expert groups, coordinators, training and guidelines on issues such as bycatch, stranding events, entanglement response and whale watching. This helps explain why, in 75 years the Commission has grown from 15 whaling nations to 89 member governments and a large body of observers and contributors reflecting the broad stakeholder interest in cetaceans, their conservation and management.

Assessing respiratory microbiome of small- and medium-sized cetaceans using unmanned aerial systems: Breath sampling humpbacks is so 2016.

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Despite the increased use of unmanned aerial systems (UAS) in marine research, there have been no documented attempts to use drones to collect samples to examine respiratory microbiome in small and medium-sized cetaceans. Remote methods of breath sampling for assessment of the respiratory microbiome, including pathogens, has the potential to minimize harassment of individuals, reduce biases in sampling associated with reactions to vessels, and maximize sampling at reduced economic costs. In 2018 and 2019 we carried out UAS breath sampling feasibility assessments with two species of medium-sized odontocetes off Hawai'i Island. UAS sampling was undertaken with short-finned pilot whales and false killer whales at an altitude of approximately 2 m above the surfacing animal. Three different drones (DJI Inspire 2, Phantom 4 Pro, Mavic 2 Pro) were used to collect nine animal samples (two from false killer whales, seven from short-finned pilot whales) from a total of thirteen attempts. No reactions were detected for nine attempts; for three, reactions were minimal (e.g., individual rolling to look at drone). During an attempt on a logging pilot whale the individual rolled on its side and associated non-target individuals responded and abruptly dove, although all returned to pre-attempt behavior within two minutes. From 2018 sampling, two of four breath and three of four control samples yielded sufficient DNA for ribosomal DNA sequencing. Preliminary results revealed common seawater microbes (SAR11 and *Prochlorococcus*, ≥98% nucleotide match) from control samples while the best breath sequence was *Methylobacterium*sp. (99% nucleotide match), a facultative methylotrophic bacterium that could be environmentally derived. These proof-of-concept studies demonstrate the ability to use drones to breath sample medium-sized odontocetes that may not be readily approachable by boat for traditional pole-based sampling. The operational system and protocols in development will increase the reliability of sample collection while minimizing reactions in future efforts.

Passive acoustics identifies a new blue whale population in the Indian Ocean

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Blue whales were brought to the edge of extinction by 20th Century's commercial whaling. While some populations are increasing, the recovery rate of blue whales in the Southern Hemisphere has been slow, and they remain classified as endangered by the IUCN Red list. Ironically, although the blue whale is the largest animal on Earth, they have been difficult to study in the Southern Hemisphere; thus our knowledge about their population structure, distribution and migration, remains sparse. Blue whales within a

population produce highly stereotyped songs allowing us to distinguish, and monitor different 'acoustic populations'. We examined whether a blue whale call (the 'DGD-call') that had been described as a call-variant of a known population, was in fact produced by a different, and as yet, unknown blue whale population. Using a signal processing algorithm we identified the prevalence of the DGD-call in 17-years of continuous hydroacoustic data recorded at two North Indian Ocean sites. We show that rather than being a variant call, that across the 17 years the DGD-call dominates the underwater soundscape recorded at these sites. Seasonal differences in call detections between our recording sites shows that a large part of the DGD-whale population remains year-round in these tropical waters, and that the whales may migrate from West-to-East annually, instead of the classical North-to-South migration. We argue that the DGD-producing blue whales are an entirely different population, which questions the usual belief of a single blue whale stock in the Northern Indian Ocean. This study highlights the use of passive acoustic monitoring, and shows that for the blue whales of the Southern Hemisphere, this is an efficient approach to study this cryptic species.

The climate vulnerability of U.S. marine mammal stocks in the western North Atlantic, Gulf of Mexico, and Caribbean.

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Changing ocean conditions and extreme weather events associated with climate change may be especially detrimental for marine species that are already experiencing acute human impacts (e.g., fisheries interactions, vessel strikes, habitat degradation, chemical and/or acoustic pollution). A systematic approach for assessing climate vulnerability of marine mammals is needed to identify vulnerable species and stocks and help incorporate climate change vulnerability into management decisions. We developed a trait-based climate

vulnerability assessment framework to characterize the relative vulnerability of marine mammals in the western North Atlantic, Gulf of Mexico, and Caribbean. Forty-one subject matter experts scored climate sensitivity/adaptive capacity and climate exposure for 108 U.S. marine mammal stocks and stock groups. To score sensitivity/adaptive capacity, experts used species and/or stock life history characteristics. To score climate exposure, they used projected change in climate and ocean conditions compared to historical conditions within current stock distributions. The sensitivity/adaptive capacity and exposure scores were combined to calculate a climate vulnerability index. Of the marine mammal stocks scored, 33% had very high sensitivity to climate change, 18% had high sensitivity, 34% had moderate sensitivity, and 15% had low sensitivity. The majority of stocks scored (72%) had very high exposure to climate change, whereas 24% had high exposure, approximately 4% had moderate exposure, and no stocks had low exposure. When these factors were combined, the climate vulnerability index score was very high for 44% of the stocks, high for 29%, moderate for 20%, and low for 7%. Factors including temperature, ocean pH, and dissolved oxygen were the primary drivers of high climate exposure, with effects mediated through prey. These results can inform management decisions related to statutory mandates, seed hypotheses for further research, and identify potentially vulnerable stocks as candidates for advanced modeling, monitoring, research, and conservation.

A preliminary investigation of cetacean occurrence and diversity around Hainan Island in the South China Sea.

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1. The South China Sea (SCS) is known to support diverse wildlife, yet the cetacean fauna is poorly investigated. To fill this knowledge gap, we used multiple ways to conduct a pilot investigation around Hainan Island in the SCS.

2. First, we reviewed available records on cetacean stranding around Hainan from 1978 to 2016. Second, a local ecological knowledge (LEK) dataset was obtained through large-scale questionnaire-based interviews with 510 fishermen around Hainan. Lastly, we yearly carried out boat-based surveys in this region since 2014.

3. *In total, we obtained 112 stranding records, which involved 17 cetacean species, (5 baleen whale species and 12 toothed whale species). We established the Database of Cetacean Stranding Records around Hainan Island (DCSRHI, http://www.cetacean.csdb.cn/) and a cetacean rescue network in this region. Our LEK dataset served as conservation-valuable information source to investigate by-catch of cetacean in this region, and also provided insights into effective community-based conservation through understanding fishers' experiences and perceptions of cetaceans. Combined with stranding records, our LEK dataset obtained meaningful information on coastal cetacean diversity.*

4. During ~300 boat-based survey days, we sighted 5 toothed whale species for ~50 times, with the majority of sightings involving Indo-Pacific humpback dolphins (*Sousa chinensis*). A resident population of Indo-Pacific humpback dolphins was recorded in coastal waters southwest off Hainan, which expanded the known southernmost distribution range of this species in Chinese waters by more than 300 km. Besides, we also sighted Indo-Pacific finless porpoises (*Neophocaena phocaenoides*), pantropical spotted dolphins (*Stenella attenuata*), false killer whales (*Pseudorca crassidens*) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) around Hainan.

5. To conclude, our multiple-source data indicate a high species diversity of cetacean around Hainan. More in-depth studies using novel techniques and collaborative approaches around Hainan are needed to provide baseline data for effective research, conservation and management.

Effect of whale-watching vessels on Risso's dolphins' behaviour off Pico Island (Azores).

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Whale-watching is a growing worldwide industry, with potential benefits both for cetacean conservation and sustainability of local

communities. Off Pico Island, in the Azores Archipelago, whale-watching is conducted in a critical area for Risso's dolphins (Grampus griseus). We investigated the effect of whale-watching vessels on the proportion of time that dolphins spend in different behavioural states within the categories activity state, group formation, heading, and speed of travel. These were estimated for before, during and after whale-watching interactions (i.e. whale-watching vessel approached the focal group within 200m and stayed for at least 10 minutes). We calculated the transition probability between states within each category, using a first-order Markov chain model, and used these to simulate the behaviour of the dolphins over time. From the resulting time series, we calculated the proportion of time that dolphins spend in different states. Whale-watching interactions had an effect on Risso's dolphin behaviour. During interactions with the vessels, the proportion of time dolphins spent travelling increased, whereas the proportion of time spent resting decreased, leading to an overall increase in activity levels. Dolphins also increased the time spent in very tight formation, which is a common anti-predator behaviour employed by dolphins. Moreover, observed changes in heading suggest that Risso's dolphins tend to avoid the whale-watching area during interactions with whale-watching vessels. After interactions, dolphin groups spent more time in very slow swimming speed, potentially recovering from the interaction. In light of these results, we strongly recommend the use of best available science to develop whale-watching guidance, and the inclusion of a process to improve compliance, especially considering the current interest in revising the existing local regulations. Well-designed coastal management policies, including appropriate regulations, will not only protect cetaceans, but will also positively impact tourist satisfaction, increasing the probability of tourist repeating and recommending the experience.

Proposed mechanism by which retia mirabilia dampen pulsatility in the cranial circulation of the fin whale.

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Retia are vascular plexuses found in the thorax, vertebral canal and cranium of cetaceans. Nagel and coworkers (*Science* 161: 898, 1968) demonstrated that retia dampen pressure pulses to the cerebral circulation, but they identified no dampening mechanism nor any source of potentially damaging pressure pulses. We hypothesize that each fluke downstroke generates a venous pressure pulse in the abdomen that travels towards the brain via the extradural spinal veins, and that the retia protect the brain from these pulses. In terrestrial mammals, because cranial volume is fixed, dampening cardiac pulsatility is closely linked to intracranial compliance: Arterial pulsatility is shunted into veins and cerebrospinal fluid (CSF) and then out of the cranium through compensating venous or CSF outflow, effectively bypassing the cerebral circulation. In cetaceans, we propose a similar mechanism dampens fluking pulses in cranial veins: a pulse in venous volume is balanced by a loss (hindered inflow) of arterial blood, made possible by the enlarged retial compliances. We tested this hypothesis using a mathematical lumped-parameter model of cranial hemodynamics. Retial blood volumes were obtained from dissection of six fin whales and compliances from inflation tests of fresh retial arteries. Flow was calculated from measured brain weight. Simulations showed that venous pulsatility was transmitted into the CSF and arteries. Increasing compliance of the spino-cranial rete reduced pulsatility in its flow by inhibiting arterial inflow. This inhibition effectively transferred pulsatility out of the cranium and into the thoracic rete upstream. Increasing thoracic rete compliance reduced its pressure pulses, but flow there remained pulsatile**.** These simulations show how the spino-cranial rete could redirect and dampen pulsatility from cranial veins, and the thoracic rete could absorb pulsatile energy to limit further propagation. The complementary function of two retial beds—one inside rigid bone and one outside—could protect the cerebral circulation from fluking-generated pulsatility.

Seasonal, ontogenetic and sexual variation in South American fur seal (Arctocephalus australis) diet: Insights from stable isotope analysis of whiskers and teeth.

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The South American fur seal is commonly found along the coasts of southern Brazil, Uruguay and Argentina. Main reproductive activity occurs in the Uruguayan coast in spring/summer. Males disperse to foraging grounds in autumn/winter, while females tend to remain closer to the breeding colonies. The goal of this study was to evaluate the ontogenetic, seasonal and sexual variation in resource use through stable isotope analysis. Teeth (n=22) and whiskers (n=20) obtained from stranded adult animals in southern Brazil (31-33°S) were longitudinally sampled and had their $\delta^{15}N$ and $\delta^{13}C$ values analyzed. Dentin powder was extracted from each Growth Layer Group (GLG) with a 300µ micro drill and data were attributed to age-classes according to sexes different life histories (Males: adults ≥9yr, subadults 6-8yr, juvenile 2-5yr; Females: adults ≥4yr, juvenile 2-3yr). Whiskers were sectioned every 3mm and data were attributed to seasons according to available growth-rates. Isotope mixing models (SIMMR package) were used for estimating ontogenetic (teeth) prey contribution using published isotopic data. Sex was an important factor for whisker $\delta^{15}N$ and $\delta^{13}C$ values (Two-Way-ANOVA $p<0.05$), while season was not ($p=0.5$). According to teeth GLGs data, adult and subadult male diets were diverse, with almost even contribution of demersal-benthic, demersal-pelagic, pelagic-fish and squid (17-21% each). For juvenile males, crustaceans (14%), squid (20%) and pelagic-fish (21%) were the most important. A high contribution of squid (53%) to adult female diet was found, while for juveniles, demersal-benthic fish showed almost half of total relative contribution. Our analysis showed that fur seals have sexual and ontogenetic variation in feeding preferences, which is probably related to differential energetic requirements of each sex and age-class. Both males and females seem to have a steady diet throughout the year. Males showed a much more diverse diet, which is probably a result of their dispersive nature.

The relationship between estuary ecosystem and behavior of Indo-Pacific humpback dolphin (Sousa chinensis taiwanensis) in Yunlin, Taiwan.

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The Indo-Pacific humpback dolphins inhabit near shore along the western coast of Taiwan. This species has been claimed to be associate with estuary habitat. This study is aimed to explore the association between dolphin sighting rates and estuary environmental factors, including physical factors (i.e. rainfall, runoff, turbidity…) as well as biological factors (net primary production, $chlorophyll_a$). We collected physical factors in estuary area and dolphin data collected through 45 transect-line boat surveys between 2017 to 2018. Dolphin sighting rate is positively correlated with $chlorophyll_a$ while it is negatively correlated with runoff and rainfall. Behavioral analysis indicates feeding behavior is negatively correlated with low turbidity while traveling behavior is positively correlated with high concentration of $chlorophyll_a$. High turbidity can decrease photosynthesis of algae and thus reduces productivity and further influence the dolphin activity through food web. Overall, the environment factors affect the dolphin activity through food web in estuary.

Food-risk trade-off in the Indo-Pacific humpback dolphin: An exploratory case study.

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Based on the optimal-foraging theory, animals are expected to maximize foraging benefits whilst minimizing risks. Despite being highly subjected to anthropogenic impacts such as water contamination, marine traffic and underwater noise, estuaries have been identified as the preferred habitat of Indo-Pacific humpback dolphin (*Sousa chinensis*, IPHD). However, it still remains unclear why this endangered species favour such risky habitats. Here, we conducted an exploratory case study in Zhanjiang estuary (China) to test the assumption that IPHD select estuaries habitats as a trade-off that maximizes foraging opportunities whilst minimizing mortality risk. We showed that IPHD accept greater mortality risks for higher food reward, but select habitats with lower risks when food rewards are similar between two locations. Although this type of data is important to underpin

individual based models for dolphins, its principle role is to show environmental protection agencies why IPHD favours estuaries despite increased mortality risks. Habitat Conservation Plan should carefully consider prey stocks, possibly through the presence of marine protected areas near estuaries, as local overfishing may lead vulnerable cetacean populations to take greater risks.

Quantifying ringed seal lair habitat and emergence timing in the eastern Bering and Chukchi Seas

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Climate warming presents considerable challenges for Arctic marine mammals that have evolved a strong dependence on snow and sea ice. Ringed seals *(Phoca hispida)* are ice-associated Arctic pinnipeds that are a vital resource for Arctic indigenous peoples, and are ecologically important as the primary prey for polar bears. These seals rely on snow-covered lairs in the spring to protect their pups from hypothermia and predation when they are young and vulnerable. There is a paucity of information on the amount and duration of snow required for pupping, and the timing of seal emergence from snow lairs. In this study, we use observations of ringed seals during the spring denning period from two extensive aerial surveys conducted in the Bering (2012-2013) and Chukchi Seas (2016). In total, these surveys covered 116,000 km of survey track and detected 8,449 ringed seals. Both surveys were a product of U.S.-Russian collaboration, and used a combination of thermal and color cameras to detect ringed seals on sea ice and categorize them by age class. We use generalized additive models to describe increases in the number of ringed seal detections (pups and adults) over the spring denning period (April-May) as they emerged from snow lairs. This time series of emergence provides information on the optimal timing for future aerial surveys, information sorely needed to quantify trends in abundance. We further relate trends in emergence to environmental covariates that are expected to shift under climate change, including snow depth, melt onset, temperature, and precipitation derived from satellite passive microwave data and regional reanalysis. This study thereby provides valuable information on the importance of snow and sea ice to ringed seal reproductive ecology, with implications for the species' future in a warming Arctic, and will inform successful monitoring and management.

Will conservation translocations play a critical role in maintaining future marine mammal biodiversity and are we ready for Ii?

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Continued anthropogenic and natural threats have pressed several marine mammal species and populations to the brink of extinction and beyond, and many more are on course for the same fate. As these conventional threats intensify, the reality of climate change as both a direct threat and driver of secondary pressures is becoming increasingly apparent. Conservation translocation encompasses a suite of tools to conserve species and populations, and effective application of these techniques to terrestrial plants and animals has seen explosive growth in recent decades. However, for marine mammals their application is relatively uncommon. These highly manipulative techniques, which foster species' recovery, are rarely considered in the marine mammal community for several reasons. Individuals may object philosophically to the notion that translocations amount to "playing god". For others, the risks and consequences of failure may seem intolerable, especially given that marine mammals present a unique set of challenges that may increase dangers associated with translocation. For many species, significant gaps in our knowledge regarding their habitat needs, physiological/stress limitations, social dynamics, population genetics, and a myriad of other variables erode confidence in our ability to successfully design and execute translocation programs. This presentation will review past and ongoing marine mammal translocation efforts, their justifications and lessons learned; discuss institutional hurdles our Society needs to overcome to normalize these techniques; and introduce IUCN and marine mammal specific guidelines and other tools to help inform translocation planning. As we face increasing threats to marine mammal biodiversity, conservationists should shift from reactive thinking and interventions to being more predictive and consider all potentially beneficial interventions, including conservation translocations. This will require changes in attitudes, policies, and foci of attention to overcome obstacles that cause scientists, managers, and others to avoid considering translocation until it is too late to reverse species' decline.

Media coverage on cetacean stranding in Chinese waters, 2007-2018: A source of

information for a nationwide stranding recording network.

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Systematic recording of cetacean stranding provides lots of significant information and valuable basic data for conservation actions, yet an effective nationwide stranding recording system is still lacking in Chinese waters. Media coverage, serve as an important approach to obtain information, providing us with an economical method of collecting data to establish the national network. In the present study, 1083 media reports were collected and analyzed on cetacean stranding from 2007 to 2018. A total of 1,334 individuals were recorded in these reports, which could be identified at least 7 species of Mysticeti (n=54) and 22 species of Odontoceti (n=1280). Among them, Finless porpoises (*Neophocaena phocaenoides*), Indo-Pacific humpback dolphins (*Sousa chinensis*) and bottlenose dolphins (*Tursiops truncatus*) were the most common species, consisting of 49.18%, 8.77% and 3.52%, respectively. With the highest number of reported stranding in Taiwan Province (n=179), followed by Guangdong Province (n=154), Hong Kong (n=127) and Fujian Province (n=111). The diversity of stranded cetaceans was highest in Fujian Province, with 20 species involved. Cetacean stranding occurred in all months, but most frequently recorded from March to May (35.83%). In the recent decade, the annual numbers of media coverage on cetacean stranding in Chinese waters increased significantly ($t=6.16$, $p<0.01$), which might not only due to the increasing individual of stranding, but also reflect an increasing public response and conservation awareness on such events. Although the growing social attention, some problems are still existing on media coverage, such as the lack of comprehensive and detailed, which limits a great knowledge of the status of cetaceans. Hence the standardization of media reporting is recommended to providing accurate information source, and the establishment of an effective nationwide stranding recording network to promoting the scientific management and effective conservation of Chinese cetaceans.

Trade-offs between age-related reproductive improvement and survival senescence in highly polygynous elephant seals: Dominant males always do better.

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Life history trade-off theory predicts that current reproduction negatively affects survival and future reproduction. Few studies have assessed reproductive costs for males of polygynous species compared to females, despite substantial variation in reproductive success among individual males (e.g. subordinate *cf*. dominant breeders). Specifically, differentiating between the costs of attending a breeding season and the additional costs of successfully mating females is lacking. We investigated whether trade-offs are present in the highly polygynous male southern elephant seal (*Mirounga leonina*) using 34-years of individual-level data. We compare age-specific survival and reproductive probabilities of breeders (subordinate and dominant) and pre-breeders (males yet to recruit) using multievent models. Pre-breeders and breeders of overlapping ages had similar survival probabilities, suggesting that there was no attendance cost for early recruits. In addition, the probability of recruiting as a dominant breeder never exceeded recruitment as a subordinate breeder of the same age, but chances were much improved by the oldest age class. When comparing subordinate and dominant breeders, we found clear evidence for survival senescence, with subordinate breeders having a higher baseline mortality. In contrast, age-specific reproductive success (measured as social rank) increased with age, with dominant breeders maintaining higher subsequent reproductive success. These opposite trends in breeder survival and reproductive success may indicate a lifetime, population-level trade-off. However, we found no evidence to suggest that being a dominant breeder consecutively (and having a higher accumulated reproductive cost) accelerated the rate of senescence when compared to individuals that were previously subordinate. Thus, breeders experienced actuarial senescence regardless of mating success, with dominant (and possibly high quality) breeders reducing the trade-off between survival and reproductive success. We make several novel contributions to understanding polygynous male life histories and southern elephant seal demography.

Foraging-site fidelity and behavioural consistency in female Australian fur seals

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Individual specialization has profound implications for population dynamics and how species adapt to environmental variability and, therefore, understanding the degree of inter- and intra-individual variation within populations is important for predicting how species may respond to future changes in their ecosystem. The Australian fur seal (*Arctocephalus pusillus doriferus*, AUFS) represents the largest marine predator biomass in south-eastern Australia, currently one of the fastest warming oceanic regions in the world, and is expected to experience significant changes to the distribution and abundance of prey. While numerous studies have investigated the at-sea movements and diving behaviour of female AUFS, revealing they forage almost exclusively on the sea floor of the shallow continental shelf of Bass Strait, little is known of the degree of individual behavioural consistency within the species. The present study investigated foraging site fidelity and behavioural consistency in female AUFS provisioning pups from Kanowna Island (northern Bass Strait). Matched data from females instrumented with GPS and dive behaviour data loggers conducting ≥2 foraging trips (4.7 ± 0.5) were obtained from a total of 36 individuals. Bhattacharyya's Affinity Index on the overlap of 95% foraging area utilization distributions within individuals ranged from 0.004 - 0.85 (0.21 ± 0.17), suggesting a generally low degree of foraging site fidelity. However, Variance Components Analysis indicated that individuals accounted for moderate-high (40-60%) proportions of the variation in foraging behaviour metrics. Using the co-efficient of variation in foraging metrics as a measure of consistency within individuals revealed substantial differences in specialization between individuals. Of the intrinsic variables investigated, linear models indicated relationships only for Standard Length and the degree of consistency in dive duration and dive depth (both positive). The observed variability of foraging specializations and low fidelity to foraging sites, provides insight into the adaptability of AUFS under the constraints of future environmental variation.

Structure and mechanical properties of Southern Right and Pygmy Right whale baleen.

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Baleen is a resilient and keratinised filter-feeding structure attached to the maxilla of mysticete whales. It withstands extreme pressures in the oral cavity during feeding, making it a strong and tough, yet pliant and resilient material. We investigated the structure, water content, wettability and mechanical properties of baleen of the Southern Right *Eubalaena australis* (SRW) and Pygmy Right whale *Caperea marginata* (PRW), in order to understand the effects of hydration on the physical and mechanical properties of baleen. Sixty 25x15mm baleen specimens of each species were prepared: half were hydrated in circulated natural seawater for 21 days and half were dry. Water content analysis showed that SRW baleen was 21.2% water weight and the PRW was 26.1%. Wettability testing indicated that the surfaces of both hydrated and dried SRW and PRW baleen were hydrophilic, with hydrated samples of both species having lower contact angle values. For the SRW, the average contact angle of hydrated baleen was 40° ± 13.2 and 73° ± 6 for dried samples. Hydrated PRW baleen had an average contact angle of 44° ± 15.3, which was lower than in dried samples (74° ± 2.9). Three-point bending mechanical tests showed that the average maximum flexural stiffness of dried SRW (134.1 ± 34.3 MPa) and PRW samples (117.8 ± 22.3 MPa) were significantly higher than those of hydrated SRW (25.7 ± 6.3MPa) and PRW (19.7 ± 4.8 MPa) baleen. Scanning electron microscope images showed the stratification of the outer cortical layer, with cross-linked keratin fibres observed within and between baleen keratin sheets. Hydrated baleen, similar to its natural and functional behaviour, has greater flexibility and strength, attributes necessary for the complex filter feeding mechanism characteristic of whales. The effects of hydration must be considered in studies addressing the physical and mechanical properties of baleen, especially those using dried museum specimens.

Genetic assignment of humpback whales, Megaptera novaeangliae, from feeding grounds in the eastern North Pacific to Distinct Population Segments.

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Humpback whales undertake a seasonal migration from warm-water, winter breeding grounds to high-latitude summer feeding areas. During this annual migration population segments overlap on migration corridors and in shared feeding destinations, creating a mix of multiple breeding stocks or distinct population segments (DPS). At least two breeding stocks overlap on the feeding grounds along the coasts of California, Oregon and Washington: the Mexican DPS and the Central American DPS, listed as threatened and endangered respectively under the US Endangered Species Act. Entanglement rates of humpback whales on these eastern North Pacific feeding grounds have recently increased due to interactions with fisheries activity. This increase in entanglement rates has raised concern about exceeding limits of Potential Biological Removal (PBR) allowed under the US Marine Mammal Protection Act for these management stocks. Here we present genetic differences between feeding aggregations and assignment to DPS for n = 864 samples of humpback whales sampled in the eastern North Pacific, using a standard DNA profile of genetic sex, mtDNA haplotype and 10 microsatellite loci. Preliminary analyses indicate mtDNA haplotype frequencies differ by latitude for humpback whales feeding in California, Oregon, and Washington, representing different proportions of individuals from each DPS in mixed-stock feeding aggregations. Population assignment procedures using microsatellite genotypes allow a probabilistic assignment of individuals to DPS and an alternate estimate of mixing proportions. Greater confidence in assigning individuals to DPS through genome-wide analysis (ddRADseq) is pending. Inclusion of genomic markers and improved analysis of breeding ground samples provides data necessary for informed management decisions, as fisheries closures could be imposed to reduce incidental mortality exceeding the allowed PBR of either DPS.

Using data collected from opportunistic platforms to assess marine mammal abundance and distribution in Cardigan Bay, West Wales

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Collecting scientific data from opportunistic platforms is becoming increasingly common due to the financial burden of line transect surveys. Opportunistic platforms provide not only the opportunity for inexpensive data collection, but also the prospect to enhance public attitudes and awareness towards the marine environment. However, the scientific robustness of such data is often questioned. Data were collected by trained Sea Watch volunteers participating and completing both dedicated surveys and observations aboard opportunistic platforms between the years of 2014-17 inclusive within the Cardigan Bay Special Area of Conservation in West Wales. Data collected from opportunistic platforms and dedicated surveys were compared to assess the potential of using the former to accurately estimate population abundance and sighting rates and for visualising potential marine mammal hot spots. Opportunistic and line transect data showed similar trends and gave an insight into sighting hot spots. Although dedicated line transect data can yield absolute abundance estimates with much improved confidence levels compared to data collected from opportunistic platforms, this study highlights that data collected from opportunistic platforms such as wildlife trip boats should not be disregarded as they may provide a broad understanding of distribution and trends at lower cost and pinpoint areas that may benefit from further more refined study.

Seal and polar bear behavioral response to an icebreaker vessel in Petermann Fjord, Northwest Greenland.

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Icebreaker vessels are important scientific tools, enabling access and research within the polar regions of the world. These vessels have the potential to overlap with marine mammal habitats in infrequently studied areas. Marine mammal

behavioral responses to icebreaker vessel presence and distance are not well documented or understood. During the Petermann 2015 Expedition on icebreaker *Oden*, seal and polar bear (*Ursus maritimus*) data were collected in Petermann Fjord (Northwest Greenland), adjacent Nares Strait region, and transit to/from Thule, Greenland July 30 – August 30, 2015. We examined behavioral responses from four seal species: bearded (*Erignathus barbatus*), ringed (*Pusa hispida*), harp (*Pagophilus groenlandicus*), and hooded (*Crystophora cristata*) and the polar bear to an icebreaker vessel in a rarely studied region. We investigated rate of flush response, entering the water from a previously hauled out location on ice, in relation to seal distance to icebreaker. Our results showed significant difference (independent t-test, $P \leq 0.001$) between seal distance to vessel when a flush response occurred (mean = 467.1 m, SD = 212.39 m) and when no flush response occurred (mean = 1334.0 m, SD = 433.89 m). There were fewer flush responses by seals at distances > 600 m and no flush responses by seals at distances > 800 m. We used a logistic model to describe the relationship between the proportion of seals that flushed and distance from the icebreaker; estimated distance at which 50% of the seals flushed was 709.45 m (SE = 9.24, $t = 76.8$, $P < 0.0001$). Three polar bears were recorded during transit and a behavioral response (e.g. look, approach, move away) was recorded for all three sightings. Our preliminary findings are relevant to assess potential impacts of increasing vessel activity in the Arctic and to assist in the development of effective monitoring and mitigation strategies.

Investigating growth layer group deposition in the earbones of old Florida manatees via tetracycline marking

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Tetracycline is an injectable antibiotic commonly used for validating animal age estimation methods because it gets incorporated into bone during active mineralization, fluoresces under ultraviolet light, and persists in samples for many years. Tetracycline was used previously to determine the annual rate of growth layer group (GLG) deposition in earbones of Florida manatees (*Trichechus manatus latirostris*), but sample size was limited (n=3) for manatees >15 years old. GLG counts in earbones from manatees >15 years old often underestimate age, a finding attributed to increased resorption (bone turnover) in older animals. An alternative hypothesis is that earbone GLG deposition rate varies with age. To investigate GLG deposition in older manatees, we analyzed earbones from 11 manatees that were injected with tetracycline and were recovered dead 6–37 years later. Cross-sections of earbones were photographed under ultraviolet light to document the location of tetracycline mark(s) and then processed to visualize GLGs. Individual case histories were compared to blind GLG age estimates and estimated years since injection, based on the location of the tetracycline mark(s) relative to GLGs. Nine manatees had at least one earbone that fluoresced. Age was underestimated for the five manatees that were known the longest (>26 years). Years since injection was underestimated for five manatees and overestimated for two manatees. Heavy resorption was present in only three of these seven inaccurate cases, suggesting that there may be other reasons for error. These could include time in managed care, exposure to different environmental stressors, and changes in somatic growth with age, which all might affect bone growth and GLG deposition. Ultimately, GLG deposition may be more variable in manatee earbones than expected, particularly for older individuals, which influences the accuracy of age estimates. The growth dynamics of tissues should be considered when validating age estimation methods for marine mammals.

Haul-out behavior and detectability of bearded, ribbon, and spotted seals in the Bering and Chukchi sea

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Ice-associated seals rely on sea ice for a variety of activities, including breeding, molting, pupping, and rest. In the Arctic, many of these activities occur in spring and early summer as sea ice begins to melt and retreat northward. Rapid acceleration of climate change in Arctic ecosystems is thus of concern, as the quantity and quality of suitable habitat is forecast to decrease. Here, we use data collected from bio-loggers deployed

between 2005 and 2017 to investigate the seasonal timing and environmental factors affecting sea ice use by bearded, ribbon, and spotted seals in the Bering, Chukchi, and Beaufort Seas. In addition to providing baseline data on phenology, these data also allow us to refine availability estimates needed to accurately estimate abundance from aerial survey counts of seals basking on ice. Using generalized linear mixed pseudo-models to properly account for temporal autocorrelation, we fit models with a variety of covariates (e.g., day-of-year, solar hour, age-sex class, wind speed, barometric pressure, temperature, precipitation) to explain variation in haul-out records. We found evidence for strong diurnal and seasonal patterns in haul-out behavior, as well as strong weather effects (particularly wind and temperature). In general, seals were more likely to bask on ice mid-day and when wind speed was low and temperatures were higher. Haul-out propensity increased through March and April, peaking in May and early June before declining again. The timing and frequency of haul-out events also varied based on species and age-sex class. For ribbon and spotted seals, models with year effects were highly supported, indicating that the timing and magnitude of haul-out behavior varied among years. This analysis suggested a large degree of plasticity in the timing of annual haul-out peaks, indicating they may have the ability to adapt breeding, molting, and pupping to environmental conditions.

Monitoring acoustic labels to determine abundance and individual movement of coastal bottlenose dolphins, Tursiops truncatus

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Mark-recapture is commonly used for studying abundance, survival and movements of wild animals. For cetaceans, photographic mark-recapture is widely used but it is limited to day-light hours and good weather conditions, is expensive, time consuming and causes some level of disturbance. Fixed hydrophones offer a non-invasive alternative to capture individuals using acoustic labels – individually unique signature whistle types (SWTs). Over 50 years of research into signature whistles indicate a high degree of uniqueness and stability, making them ideal 'marks' for mark-recapture. We investigated the potential to use static acoustic monitoring (SAM) to detect individual bottlenose dolphins using their SWTs and analysed the data within a mark-recapture framework. Data were collected from four moored hydrophones located in Walvis Bay, Namibia. We investigated the influence of location and duration on SWT detection, by comparing data from 22 synchronised recording days at 4 sites; and 124 days of data from one high-use site. SWTs were identified using a bout analysis approach (SIGID, Janik et al., 2013). There was high variability in SWT capture rates between sites (range 0 to 13 SWTs detected). This variation may be partly explained by differences in background noise, detection ranges and/or differences in behaviour at each site (e.g. travelling/socialising). At the high-use site, 47 SWTs were captured over six months. Boat-based surveys (n= 29) carried out across the bay identified 54 animals photographically during this time. Discovery curves showed an initial increase in newly detected SWTs, approaching asymptote around 100 days. A Huggins closed capture model using months as capture occasions calculated 78 individuals (71 to 92 95% CI) which overlaps with the known population size (Elwen et al. 2019). This study indicates the potential power of using acoustic labels as proxies for individual occurrence but also highlights some potential sources of bias that may occur.

Distribution, abundance and residency time of humpback whale mother/calf pairs off NW Boa Vista or why to protect the Bay of Sal-Rei and adjacent waters

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The Cabo Verde Islands constitutes the only known breeding ground for humpback whales in the eastern North Atlantic. Research activities of this population began in 1991. Since 2008, whale watching boats have been used as platforms of opportunity to monitor the population off the west coast of Boa Vista. The breeding season occurs between February and May. Fluke matches have been found between Cabo Verde and high latitude feeding grounds off Norway, Iceland and Ireland. The Bay of Sal-Rei has been identified as the single most important habitat for winter breeding, calving and nursing whales in the eastern North Atlantic. Cabo Verde Islands/Northwest Africa is regarded as one of the four humpback whale distinct population segments listed as endangered. Based on photo-identification, the small Cabo Verde humpback whale population (<300 individuals) has relatively high inter-annual re-sighting rate (ca. 50%) that suggests strong site fidelity to this breeding ground. Here we present inter-annual fluctuations in the spatial and temporal distribution, numbers and residency time of mom/calf pairs in Sal-Rei Bay and adjacent waters (<70 m deep) over the last three breeding seasons (2017, 2018 and 2019). Residency time has been defined as the minimum number of days that individuals remained in the same area. Results were quite consistent in 2017 and 2018, in terms of number of MC pairs (14 and 16, respectively), maximum residency time (ca. 30-35 days) and average residency time (ca. 8 days).Preliminary results for 2019 breeding season are pending analysis but does include a minimum of 14 mom/calf pairs.These results may have important implications for conservation and management measures that could contribute to the recovery of this endangered population, including the delimitation of a marine protected area and the regulations of human activities that could have a detrimental impact to these animals.

Impact of past climate changes on narwhal population structure and demographic history.

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Climate warming is currently happening at an unprecedented pace on our planet. However, Earth has experienced severe climatic oscillations in the past. Understanding the responses of species to past climatic perturbations can provide useful insight into their resilience to on-going and future climatic shifts. The Arctic is experiencing warming at 2-3 times the rate of the rest of the planet and has already undergone major changes in the last few decades in terms of sea ice cover (declines) and air and ocean temperatures (increases). However, predicting how these changes are likely to impact endemic Arctic marine mammals is challenging due to a lack of information regarding how past climatic shifts have impacted the populations of these top trophic animals in the Arctic. The narwhal is considered to be one of the most vulnerable Arctic marine mammals to sea ice losses because of its limited distribution and narrow ecological niche. Here, we present complete mitogenomes and low-coverage nuclear genomes from narwhal samples (n=121) collected across the present distribution range of the species. We find low levels of genetic differentiation and a lack of geographic structuring of mitochondrial haplotypes. Demographic history analyses indicate that narwhal effective population size increased threefold after the Last Glacial Maximum (LGM), from ~9,000 years BP. This expansion is correlated with a drastic post-glacial increase in the amount of suitable habitat available for narwhals, as inferred from species-distribution models. The response of narwhals to post-LGM deglaciation is in marked contrast to the patterns seen for Arctic terrestrial mammals, which showed population declines or extinctions. However, it mirrors the responses of several marine top predators in the Southern Ocean, which experienced population expansions following the release of new breeding and/or foraging habitats. Our analyses suggest the amount of available habitat has been critical to the success of the narwhal.

Behavioral effects of sound from marine geophysical surveys on marine mammals: A literature review.

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There are numerous recent reviews of marine mammal behavioral responses to underwater sound. However, these reviews fail to characterize biases in both literature selection and within and between reviewers. We have quantified inconsistency and bias, both in the literature and the subsequent review. We evaluated original sources on behavioral effects of anthropogenic sound, emphasizing sound sources used in geophysical surveys.

An initial review by five independent reviewers determined the most impactful and relevant literature for inclusion in the review. Reviews were assigned using a modified Gellerman series to balance the number of reviews and combinations of reviewers. A double-blind control process was implemented in the analysis of the results. A subset of references, including references for which there was disagreement among reviewers and those for which agreement was unanimous during the initial review, was then re-reviewed using the same design, providing a robust basis for quantifying inter- and intra-reviewer variability.

This review demonstrated that the reported and utilized sound source are frequently inconsistent; for example, utilizing playback of a sound source inconsistent with actual usage parameters, especially for large specialized sources like military sonars and seismic survey arrays. It is often difficult to extrapolate results from these proxy sound sources to responses produced by the actual sources of concern. Additionally, many studies characterize only short-term changes in behaviors, but the extent to which the reported effects persist is unclear. Without a durational component it is impossible to determine the potential long-term impacts to the animals, leading to tendencies to speculate unscientifically about the potential long-term outcomes. Finally, this review confirmed that observer bias, even among experts, is an unavoidable outcome in any literature review and should be factored into any literature review process.

Marine mammals seeking for prey in tridimensional environments

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Within pelagic domains, marine mammals exploit tridimensional environments seeking for prey. Understanding the drivers of predator-prey interaction is a long-lasting issue in ecology. Based on integrated ecosystem surveys that collected simultaneously multi-trophic information and oceanographic characteristics, we described the tridimensional environments of marine mammal species in the temperate ecosystem of the Bay of Biscay. For that, we combined estimation of prey biomass using acoustic methods and oceanographic characterisation based on a multidisciplinary approach to model marine mammal abundance during the 2013-2018 period. During early autumn, common Delphinus delphis and bottlenose dolphins Tursiops truncatus were observed on the continental shelf, while Cuvier's beaked whales Ziphius cavirostris and long-finned pilot whales Globicephala melas were observed on the continental slope and striped dolphins Stenella coeruleoalba and fin whales Balaenoptera physalus in the oceanic area. Predator-prey relationships were explored from a functional point of view by considering prey characteristics such as prey availability, depth, body size and energetic content. Pelagic prey considered were 6 species of fishes (European anchovy Engraulis encrasicolus, European pilchard Sardina pilchardus, European sprat Sprattus sprattus, Atlantic horse mackerel Trachurus trachurus, Atlantic Mackerel Scomber scombrus and Mueller's pearlside Maurolicus muelleri) and 1 crutacean (Krill Euphasia spp.). Based on Generalized Additive Models, we developed density surface models to disentangle the effects of the 3D ocean environment and preyscapes at different depth ranges, in addition to static variables, on driving the spatial abundance of marine mammals. We validated the development of 3D predictors that integrate the outputs of integrated ecosystem surveys by identifying the biologically meaningful depth ranges linked to the ecology of marine mammals. Our outcome allows us to frame predictions about the functional structure of the pelagic network of the Bay of Biscay in autumn, and exemplifies the value of annual monitoring schemes to advance ecosystem-based management.

A review of humpback whale strandings and human interaction in Virginia and North Carolina on the southern Mid-Atlantic coast of the United States.

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The humpback whale (Megaptera novaeangliae) is the most commonly stranded baleen whale along the southern mid-Atlantic US coast. We investigated 93 stranding reports in Virginia and North Carolina, USA, from 2000 to 2019 to assess seasonality, demographics, and stranding cause. Strandings occurred in every month and every year, with significantly more (n=73) occurring in cooler months (Dec-May; W=466.5; p=0.0002). Twenty-five whales were initially sighted as floating carcasses, with 11 eventually beaching or being towed to shore. Nine events involved live strandings. Two live-stranded whales refloated independently and were not re-sighted; two died without assistance, and five were euthanized. Sex ratio was nearly equal (37 females, 34 males). Minimum and maximum lengths were 609 cm and 1,541 cm, respectively, and there was no difference in length by sex ($F_{2,82}$=0.786; p=0.459). Mean length was significantly different among 5-year periods (X^2=9.702; df=3; p=0.02;) and increased from a mean of 886 cm (±200 SD) from 2000-2004 to 972 cm (±131 SD) from 2015-2019. Fifty-six carcasses were fresh to moderately decomposed, all received an external examination, and 29 (52%) received a partial or complete necropsy. Half of those 56 (n=28) whales scored YES for human interaction (HI), three scored NO, while status HI could not be determined for 25. Twenty-two carcasses displayed lesions consistent with entanglement or vessel interaction, and two displayed both. Four cases scored YES, but the cases could not be reviewed further, and lesion/HI type was not determined. Of 13 carcasses with entanglement lesions, all but two had recent/healing lesions that were suspected to be associated with the stranding. Of the 13 with vessel interaction lesions, seven had lesions consistent with blunt trauma and six had propeller lesions. These results demonstrate that humpback whales are year-round visitors to the mid-Atlantic and that the leading cause of strandings are anthropogenic.

Antarctic fur seal males: Tourists, trouble makers or an appropriate sentinel of the Antarctic marine ecosystem?

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In the Antarctic, seals and seabirds are used to monitor change in marine ecosystems arising from climate change or other anthropogenic impacts such as fishing. The logistical constraints imposed by the remote location and harsh climate of the Southern Ocean has resulted in monitoring programmes focusing on species that are accessible during the austral summer at land-based sites. For example, various species of seals and seabirds are monitored during breeding at colonies along the West Antarctic Peninsula (WAP) and Scotia Sea, the region of Antarctica experiencing the most rapid warming and the primary area for Antarctic krill fishing. Foraging and breeding indices of these predators have been used to infer changes in krill availability in this region. However, adults that provide parental care must return regularly to land to feed dependent offspring, restricting how much time can be spent at sea. Consequently, breeding and foraging indices derived from parents will only integrate information over restricted parts of the marine environment and inferring changes in prey variability from such predator indices may be flawed. To highlight this limitation, we use data from an unmonitored and unconstrained life history stage of a monitored species; adult male Antarctic fur seals. We present data collected from 18 individuals instrumented with electronic tags on the South Orkney Islands shortly after breeding. Using telemetry data in addition to biogeochemical markers from whiskers, we demonstrate that the pattern of foraging is consistent over years, overlaps in time and three-dimensional space with breeding chinstrap penguins (a monitored species) and that they use the same areas as the krill fishery. We suggest that indices collected from unconstrained predators may be more informative regarding ecosystem change than those currently used, which do not integrate information across

large areas and may be subject to interference competition from unmonitored species.

Amino acid nitrogen isotope values as new tool for identifying fasting events in free-ranging marine mammals

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Bulk tissue stable isotope values measured chronologically along the length of metabolically inert but continuously growing whiskers collected from adult females or pups can be used as a nutritional biomarker to retrospectively reconstruct the diet of the mother during gestation. Yet, it is increasingly recognized that physiological factors associated with fasting or reproduction may confound this interpretation. To quantify the effects of fasting and gestation on nitrogen isotope (δ^{15}N) values, we measured δ^{15}N of both bulk keratin tissue and its constituent amino acids along the length of whiskers sampled from adult female southern elephant seals (*Mirounga leonina*) captured on Marion Island in the Southern Ocean. The significant δ^{15}N enrichment (~2–6‰) of most glucogenic amino acids and simultaneous depletion (~2–3‰) of the alanine δ^{15}N values observed during known periods of fasting enabled us to accurately predict (74%) whether animals were in a catabolic (fasting) or anabolic (feeding) state during the period when the whisker growth occurred. The mechanism by which fasting affects the δ^{15}N values is explained with reference to the glucose-alanine cycle. In addition, we assessed the use of isotope values measured in tissues from paired mothers and pups (n = 15) to hindcast the foraging ecology of breeding females during gestation and assess the accuracy of isotope-based dietary reconstructions. Contrary to expectations, the mother-pup whisker isotope values were not linearly correlated, and δ^{15}N discrimination between moms and pups changed as gestation progressed. It is evident that physiological factors have an under-appreciated influence on δ^{15}N values, which can lead to erroneous isotope-based dietary reconstructions. This study also provides proof-of-concept that an isotope-based approach can be used as a nutritional biomarker for assessing the state of nitrogen-balance of an individual.

Standardization of protocols for quantifying GST activity and CYP1A levels in integument biopsies of Tursiops truncatus, Stenella longirostris and Balaenoptera brydei

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The widespread occurrence of xenobiotics in marine waters has prompted the development of pollution monitoring programs to guide the conservation of marine mammals, focused on determining contaminant levels and evaluating the biological related-effects on biota through the analysis of biomarkers. Nonetheless, their use may be limited due to the absence of standardized methods specific to integument of cetacean species. Thus, this study aimed to standardize the protocol of two classic biomarkers: glutathione *S*-transferase (GST) activity and cytochrome P450 1A (CYP1A) immunodetection in integument of *Tursiops truncatus*, *Stenella longirostris* and *Balaenoptera brydei*. The samples were collected during the Cetacean Monitoring Project (PMC-BS), required by Brazil's federal environmental agency for the environmental licensing process of oil production and transport by Petrobras at the Santos Basin pre-salt province. For the GST activity, kinetic curves were constructed for the substrates 2,4-dinitrochlorobenzene (CDNB) and reduced glutathione (GSH), and fitted to Michaelis-Menten non-linear regression. For CYP1A immunodetection, microssomal protein loads and antibody (primary – ABCAM 126887 and secondary – ABCAM 205723) dilutions were tested for each species, and optimal parameters were established by chemiluminescence. For GST activity, optimal CDNB and GSH concentrations were: 12.4-24.9 mM and 3.5-7.0 mM for *T. truncatus*, 12-24 mM and 2.1-4.3 mM for *B. brydei*, and 12.5-25 mM and 2.1-4.3 mM for *S. longirostris*, respectively. Regarding CYP1A, 10 µg was the optimal protein load, and primary and secondary antibodies dilutions were established at 0,1 µg/mL and 0,15 µg/mL, respectively, for *T. truncatus* and *S. longirostris*, and the secondary antibody at 0,3 µg/mL for *B. brydei*. Results indicate similarity among species, suggesting that tissue features might be more important than species for analytical standardization. Nonetheless, optimal substrate concentrations obtained for GST are higher than those described in standardized protocols and reinforce the need of standardization of such methods to avoid any unbiased results.

Identifying novel predictors of bycatch of protected species in static net fisheries to better inform mitigation.

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Bycatch of protected species in static net fisheries is a global conservation concern, and is currently considered the dominant anthropogenic threat to many marine mammal species worldwide. Effective bycatch mitigation remains challenging, contingent on an understanding of the underlying mechanisms that cause individuals to become entangled. We combined data collected by scientific observers and fishers to identify the strongest drivers of seal bycatch in static net fisheries along the west, southwest, and south coasts of Ireland. We included in our analysis factors relating to the type of net used (mesh size) and the environment in which they were set (distance to major seal colony, water turbidity, depth, and the occurrence of seal depredation of catch). Based on a negative binomial generalised linear model, the rate of seal bycatch significantly increased in nets with larger mesh size, when seal depredation occurred, and in waters that were more turbid. The effect of distance to major seal colonies on bycatch rates varied with season; increasing closer to colonies in spring, summer, and autumn. Our results identify reliable predictors of seal bycatch that can be used to identify future bycatch risk and target mitigation measures accordingly. This is the first study to identify the effect of water turbidity on bycatch of protected marine species. Increasing net visibility in turbid waters may provide a novel approach to mitigating against protected species bycatch in static net fisheries.

Geo-spatial analysis on oil-spill risks for marine mammals in Peru: In need of an action plan.

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Oil spills are a worldwide concern when it comes to the long-term effects that impact the marine ecosystem. Oil can be toxic through contact with skin, inhalation and ingestion. There is currently no formal oil spill response plan for Peru, yet the Peruvian coast is home to 30+ marine mammal species that are at risk or endangered. We analyzed the risks of a potential oil-spill considering the geo-spatial distribution of marine mammals to produce an efficient proposal of an oil-spill action plan. Geo-positional system coordinates were taken for fixed rockeries for three pinniped species, as well as frequency of coastal sightings and strandings of ten cetacean species. Overlap mapping of these coordinates was confronted with the physical distribution of current oil platforms and gas plants. Geospatial analysis helped us to identify the areas where oil production is high: Over 40 platforms in Tumbes and Piura states in the northern coast; six oil distribution plants in Lima and Ica in the central coast, and thirteen distribution platforms are projected in Moquegua state in the south. Amazingly, these states are of ecological significance and most of the platforms are within the range of Natural Reserves, carrying >80% of at-risk species, including the endangered marine otter. Several lessons have been learned following past oil-spill events, and it is clear that prevention plans, buffer zones and safety guidelines must be developed in Peru. In the event of an oil spill, only ORCA's South Pacific Marine Mammal Center in Lima can provide medical assistance. In consequence, we found that the overall result today would be that of a high risk and a severe impact. This further proves our need to advocate for an oil spill action plan for marine mammals as the next step in the conservation and protection of coastal Peru.

Geographic variation in the acoustic repertoires of common bottlenose dolphins in the Atlantic Ocean and the Mediterranean Sea

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Intraspecific variability in acoustic repertoires is common in widely distributed species, and geographic variation in this trait has been used to distinguish populations of marine mammals. Acoustic divergence in cetaceans has been linked to ecological factors, geographical barriers, and social processes. In the case of common bottlenose dolphins (*Tursiops truncatus*) most studies of geographic variation focus on a single sound category: whistles. Here, we study the acoustic repertoires of nine bottlenose dolphin populations across the Atlantic Ocean and the Mediterranean Sea, and identify divergence patterns of shared acoustic signal elements and acoustic variants. Repertoire composition was defined based on the occurrence of different signal types and sub-types, both pulsed and tonal sounds. A similarity index derived from Dice's coefficient of association was used to assess repertoires' (dis)similarity. Our results show multi-regional richness in the acoustic repertoire of these dolphin populations, with a total of 21 nominal signal sub-types including: whistles, creaks, squawks, brays and bangs. Acoustic divergence was observed only in social signals reported as information-rich calls, namely whistles and the elements of bray sequences (e.g. squeaks, grunts and gulps). The repertoire dissimilarity values were remarkably low (from 0.08 to 0.4) and support previous work showing that signal repertoire does not mirror geographic distances among dolphin populations. The highest repertoire similarity was found between the Sado estuary, Portugal and the Adriatic Sea dolphins, which live in very similar environments. The lowest similarity was found between the neighboring populations of Gandoca-Manzanillo, Costa Rica and Bocas del Toro, Panamá that live in contrasting habitats. Our results support the 'environmental adaptation hypothesis' - geographic variations in animal acoustic repertoire may reflect local adaptations to specific environmental contexts. Geographic variation on acoustic repertoires may clarify the boundaries between neighboring populations, and shed light into vocal learning and cultural transmission in bottlenose dolphin societies.

A classification scheme for external injuries of dolphins: Towards objective quantification and comparison across space and time.

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Dolphins are impacted by a variety of threats but little is known about spatial, temporal and inter-species variation in injuries. Our review of studies which quantified the prevalence of injuries in dolphin populations shows that different criteria are being used for classifying injury types and that injuries are reported using different methods. We argue that the cause of injuries is often speculative and therefore unsuitable as the primary basis for a classification system. The lack of a universal method for reporting the prevalence of injuries in marine mammals hampers comparative studies of geographic, temporal, and inter- and intra-specific variation in the prevalence of injuries. To remedy these problems we propose a classification system for quantifying external injury types in marine mammals which defines injury types on the basis of their external morphology. We will test the proposed classification system with several photo databases. We review current knowledge about the cause(s) of these injury types and identify topics for further study. Standardized reporting of injuries will hopefully deepen our understanding of factors that affect the health and survival of marine mammal populations worldwide.

Quantifying habitat use of killer whales in Vestmannaeyjar, Iceland.

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Animal movements largely depend on the proximate (immediate) or ultimate (long term) requirements of the animal, and whether the habitat resources can meet those requirements. *Orcinus orca* are a globally distributed species, but tend to occur in higher numbers in temperate and polar regions. In Iceland, killer whales are annually sighted in the summer months on the spawning grounds of the Icelandic Summer-Spawning (ISS) herring stock, located on the gravel beds around the Vestmannaeyjar archipelago, south Iceland. To understand if killer whales occur in this region to feed on spawning herring we used ArcGIS to investigate killer whale habitat use based on data collected in July for six years, and environmental data (substrate type and depth) from the European Marine Observation Data Network (EMODnet). The location of sightings was obtained from the GPS locations of killer whale images collected during surveys. Data layers were built upon a 170m² grid, firstly intersected with survey vessel tracks, the presence or absence of orca per surveyed cell, and lastly the environmental data layers, resulting in maps of orca habitat use around Vestmannaeyjar (556 km²). A generalised linear

model tested the effect of the explanatory variables (substrate type and depth) on killer whale presence. The results showed coarse sediment, which accounted for approximately 40% of the total study area and is the material most suitable for herring spawning, was the strongest determinant of orca presence ($p < 0.0005$). Sightings' depth was also more strongly correlated with habitat suitable for herring spawning than not. This study suggests that within this region, killer whales are choosing areas suitable for herring and targeting this prey, but further research will be necessary to investigate if there are temporal or individual/group-specific variations in habitat use.

Are recent population level changes in the central North Pacific humpback whales, Megaptera novaeangliae, affecting entanglement threat and reporting rate?

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Entanglement in fishing gear and marine debris is considered a principal anthropogenic threat to large whales. Over a hundred whales are reported entangled in the North Pacific annually. In some regions scar studies have indicated that approximately 50% of the animals have been non-lethally entangled. Entanglement threat is influenced by many dynamic factors, such as gear type, the co-occurrence of animals and gear/debris, and lack of familiarity (e.g. changes in habitat use and/or fishing effort) and/or inexperience of animals (e.g. age class considerations). Changes in effort may also influence reporting. Starting in 2013, significant population-level changes (e.g. sighting rates, habitat usage, animal condition) began to be documented in the Hawaii distinct population segment. These changes likely influenced entanglement threat. While confirmed entanglement cases reported on the feeding grounds off Alaska have decreased the last 2 years, they generally have remained constant over the long-term. However, reports off British Columbia have shown a general increase since 2015. Entanglement reporting on the breeding/calving ground off Hawaii varied less, perhaps in part due to an increase in reports originating from British Columbia. Reports of subadults entangled off Hawaii have decreased, possibly as a result of greater energetic costs of entanglement and a changing environment (e.g. limited resources) on subadults. However, the rate of non-lethal entanglements, as determined through scar analysis in Hawaii, has not changed significantly over the period. The percentage of reports from Alaska feeding grounds involving nearshore-set gear, as well as, involving the mouth have tripled and doubled, respectively, perhaps a result of differences in local habitat use by whales. Information gained by evaluating entanglement risk remains our best strategy for reducing entanglement threat. However, broad-based changes, such as environmental trends and cycles, may provide additional challenges to understanding an already dynamic threat – entanglement, affecting humpback whales and other species.

Rethinking the process of whale entanglement through first person observations.

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Whale entanglement in fishing gear has been extensively studied along the East Coast of North America. Considerable work has been done to

determine when and where whales overlap with gear, but relatively little is known about the events leading up to an entanglement. Efforts have been made to model those interactions, but require data and entanglements are rarely witnessed in progress. Over the past decade, through tens of thousands of routine whale sightings, we witnessed eleven whales come into physical contact with fishing gear, including rope-based gear and monofilament from rod and reel fisheries. In all of these cases, there is at least one example of each major body area making first contact with gear and all strongly changed their behavior, exhibiting strong arches, changes in direction, surging, rolling, and/or tail flicks. Five individuals did not ultimately become entangled and returned to prior behaviors within minutes of contact and no observable injuries detected. However, more than half of the individuals became entangled (three in rope and three in monofilament). The behavioral state of all of these individuals remained altered for the duration of the observations, up to 2.75 hours. In the rope-based cases, there were multiple changes in gear configuration, including whales becoming mobile with heavy gear and the formation and loss of wraps of line to more body areas following initial contact, as a result of this behavioral response. Our observations suggest, that the configuration of gear on the body when typically viewed (days or weeks after the event) may not reflect exactly how the individual first contacted the gear. Although data remain limited, detailed study of the behavior of whales at the initial gear encounter is critical for understanding entanglements and for making effective changes to fishing practices to reduce this serious threat.

From here to there: Distance reproduction in a harbor seal.

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Harbor seals and other marine mammals regularly commute between haul-out places and feeding grounds. Mostly it was speculated that the seals' orientation and navigation abilities are based on cues derived from external sensory systems. However, at first glance the open ocean does not seem to provide many external cues for orientation. Therefore, we propose that seals might rely on information that can solely be derived from internal cues, if necessary. These internal cues could help the animal to continuously document distances travelled as a parameter for spatial orientation.

Here, we tested a harbor seal in a distance reproduction task along a 43 m long stretched belt system in the water. The seal was familiarized with a standard distance interval, which it immediately had to replicate by keeping the same swimming direction. The seal was able to reproduce a given distance very accurately and independently from its absolute position. Furthermore, it could decrease its error of replication to less than 10% when asked to replicate specific distances repeatedly. We could also show that the seal did not learn specific endpoints during the reproduction and might have focused on motor cues by swimming specific motion patterns for each given distance. Its performance was also almost unimpaired in the absence of optical cues. Thus, we conclude that distance estimation and reproduction could assist spatial orientation in the seals' natural environment, even when external information is missing.

Using whale alert in southeast Alaska: Creating safe waters for both mariners and whales.

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After discussions among stakeholders about whale strike avoidance in Southeast Alaska, the maritime community sought the ability to avoid whales and take proactive measures (i.e. reducing their speed) in areas where whale aggregation

s occur. In response, NMFS Alaska Region and National Park Service (NPS) biologists have worked together since 2011 to produce weekly whale sightings maps that improve situational awareness for bridge teams on cruise ships and the Alaska Marine Highway state ferries. Cruise ships and state ferries are the target audience because their prior experience with whale strikes motivates them to improve situational awareness and avoid collisions. These weekly maps helped to inform mariners' whale avoidance and proactive measures, however the sightings were up to a week old when delivered in this format. Real-time whale sightings were a mutual goal realized in May 2016, when mariners and biologists were able to share sightings in the Whale Alert online mapping system and smart phone applications. After the first 3 seasons of digitally capturing and reporting sightings, we'll present lessons learned and a path forward for continued conservation.

Tracking harbour porpoises around static fishing nets using PAM

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Static nets are by far the largest cause of anthropogenic mortality in harbour porpoises in UK coastal waters, with best estimates indicating

bycatch levels between 587 and 2615 individuals in 2017. Despite this, very little is known about how wild animals behave in the vicinity of nets and what the mechanism leading to entanglement is. This represents a significant barrier to the development of new bycatch mitigation strategies. Single-channel passive acoustic monitoring (PAM) devices have been previously used to record cetacean activity around static nets. These devices are generally limited to monitoring presence/absence and basic behavioural cues such as foraging buzzes. We have developed a recording system (SoundNet) which can track the fine scale three-dimensional movements of harbour porpoises (or any echolocating odontocete) around nets. The system consists of two compact four-channel recorders (SoundTraps) which record 384 kHz data for 5 days (the upper end of a typical static net soak time). Each recorder has a sample synchronised sensor package which uses 3D motion tracking technology to accurately log orientation, depth, temperature and light. Recorders are used in pairs, attached directly to the net floatline and can be deployed by hand during normal fishing operations by a trained researcher or experienced fisheries observer. Recordings are subsequently analysed in PAMGuard and the positions of animals calculated using acoustic localisation methods. We present findings from two static net deployments (each circa 2.5 days soak time) during which 10 separate porpoise encounters were recorded, two of which producing enough detected clicks to effectively track their movements. Tracks show a porpoise approaching the net and turning away when within 10 m. It is expected that continued deployments will yield a sufficiently large dataset to investigate porpoise behaviour near actively fishing static nets. This open source technology could be applied to other species and locations.

Does Guina dolphin repertoire change over time? 20 years of recording data.

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Acoustic repertoires may change in temporal and spatial scale, which can result from new social alliances, by changes in the acoustic soundscape or geographic variation. Considering the increase of the anthropogenic impacts in Sepetiba Bay (Rio de Janeiro, Brazil) over the years and the movements of Guiana dolphins (*Sotalia guianensis*) between Sepetiba and Ilha Grande bays (Rio de Janeiro, Brazil), the goals of this study are: 1) to evaluate the temporal changes in whistles of Guiana dolphins in the last 20 years in the Sepetiba bay; 2) spatially compare the acoustic repertoire between Sepetiba and Ilha Grande bays. We divided our database of acoustic recordings in two settings: "past time" (Sepetiba Bay between 1998 and 2002) and "present time" (Sepetiba and Ilha Grande bays 2015 to 2018). In order to compare whistles in temporal and spatial scale, we compared frequency contours over tow time series and between bays. We compared 200 frequency contours in each population using the ARTwarp method. For this comparison, we used a 96% vigilance with contours re-sampled at 10ms. We identify a total of 74 contour types in Sepetiba bay and 114 in Ilha Grande bay. The temporal comparison indicated 63 contour types only in the past, 4 in the only in the present and 8 in both time series. The spatial comparison indicated a total of 10 whistles shared among populations. Previews studies point to an increase of anthropic impact in Sepetiba bay and indicate that Guiana dolphins are changing their acoustic behavior over time. Thus, the observed temporal changes may indicate acoustic changes due to anthropic impacts in the bay. In addition, spatial changes indicate that even spatial separation between Guiana dolphins in this bays, they may remain social connection.

Capturing fishermen's knowledge to understand the scale and impacts of marine animal entanglement in Scottish waters from a conservation, welfare and economic perspective.

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Marine animal entanglement in fishing gear is a growing problem worldwide, considered by many to be the single most significant marine mammal welfare issue of our time. In Scottish waters the reported prevalence of entanglements over the last 20 years has remained low, but based on data

collected by the Scottish Marine Animal Stranding Scheme (SMASS) the incidence and range of affected species appears to be increasing. Entanglement in static gear has now been identified as the largest cause of non-natural mortality in Scottish baleen whales, however a thorough scientific understanding of the impacts of these incidents remains limited due to underreporting, constraints of post-mortem examinations, and the low likelihood of retrieving carcasses. In a bid to address this, the Scottish Entanglement Alliance (SEA) was established in June 2018. A partnership between six marine research, industry and conservation and welfare bodies, SEA is working closely with small-scale static fishermen to provide a co-ordinated, comprehensive monitoring and engagement programme to better understand the scale and impacts of marine animal entanglements from various perspectives. To achieve this, inshore creel fishermen have been participating in anonymous interviews regarding their fishing practices, wildlife encounters and experiences and knowledge of entanglements. To date 109 interviewed have been completed and 105 separate and previously unreported entanglement incidents involving cetaceans and other species have been recorded. This is the first time this type of research has been conducted in the UK and feedback from fishers so far is highlighting several technical, policy and social challenges surrounding entanglement in small-scale fisheries. However over 80% of those interviewed have expressed an interest in engaging in measures to reduce the risks of future entanglements. This demonstrates the potential to develop practical, industry-led solutions to this issue in Scottish waters, which will form the next stage of this work.

The impact of spatial scale on the scale of impact: Harbour porpoise Phocoena phocoena bycatch in the Celtic Seas.

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Understanding the impact of activities on populations is fundamental to conservation efforts. Impact assessments are required at a variety of spatial scales, often predefined by legislative or administrative boundaries. The use of such boundaries for impact assessments, could give rise to misleading outcomes and potentially put species at conservation risk. We used harbour porpoise (*Phocoena phocoena*) bycatch data collated by the International Council of the Seas (ICES) working group on bycatch of protected species (WGBYC) to demonstrate this issue. WGBYC supports ICES advice to the European Commission on the wider ecosystem impacts of fishing activities. ICES has undertaken several ecosystem reviews within ecoregions and WGBYC has been encouraged to conduct its assessments within ecoregions to facilitate this process. Using 2015 - 2017 data, we estimated the bycatch of harbour porpoise in gillnets in the ICES Celtic Seas ecoregion to be 230 - 471 animals per year or 0.28-0.58% of the best available abundance estimate for this ecoregion. This is less than the 1.7% threshold that ASCOBANS uses to define an unacceptable level of interaction. However, the Celtic Seas ecoregion was not based on evidence of population sub-structuring for harbour porpoise and it likely extends over two subpopulations. Therefore, we repeated the analysis within a recently defined Celtic Sea Assessment Unit (AU) that was delineated from biological information on the northeast Atlantic harbour porpoise. These results highlight a potentially more pressing bycatch problem, with an estimated 2- 6% of the unit's population taken annually. Recent survey data from this area, also show a much lower density of porpoises in parts of this AU compared to estimates from 10 years ago. Impact assessments must be carried out at biologically meaningful spatial scales if the magnitude of population-level impacts is to be understood and the need for conservation action prioritised.

Examining patterns in human interaction with bottlenose dolphins (Tursiops truncatus) and assessment of public awareness of policy: A multiple regression model provides a dual approach for understanding a conservation issue in Tampa Bay.

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It is well documented that human interaction (HI) with cetaceans can have detrimental population level effects. To mitigate this stress, the National Marine Fisheries Service has established the Southeast U. S. Marine Mammal and Sea Turtle Viewing Guidelines (henceforth, Wildlife Viewing Guidelines, WVG) to promote responsible use of bottlenose dolphin stocks in Florida; however, little work has been focused on determining the efficacy of these policies. The Eckerd College Dolphin

Project documented HI encounters opportunistically from 2009-2018, providing a long-term dataset for which boater compliance to the WVG could be analyzed. We assigned a compliance code to each HI encounter (n = 151) in our dataset for a range of compliance from non-compliant and negligent (3) to compliant (0). We then performed a stepwise multiple regression as a function of vessel characteristics, such as vessel type, in order to identify key explanatory factors for encounter compliance in the study area. Vessel activity was the key explanatory variable identified by the model for HI encounters, where vessels engaged in wildlife viewing tended toward a greater degree of non-compliance. We assessed baseline public awareness of the WVG by distributing a survey to beachgoers. We calculated a policy awareness score for each respondent (n = 225) determined by the number of questions specifically addressing the WVG answered correctly. Then we performed a stepwise multiple regression as a function of demographic data, highlighting key predictors for policy awareness. This preliminary survey provides insight on potential targets for increased public education measures as gender, education level, and age were the most important predictors of policy awareness. Thus, this study provides a dual approach for analyzing boater compliance to the WVG and public awareness of these conservation policies. Managers could use such information to better target allocation of enforcement and education resources.

Harbour porpoises modify biosonar behaviour in different environmental contexts

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Toothed whales use biosonar for foraging and navigation in a wide range of habitats from shallow rivers to coastal waters and open oceans. The ambient noise, clutter and reverberation levels that limit biosonar operation may vary widely between and within these aquatic habitats. Toothed whales must therefore cope with dynamically changing masking levels while extracting the echo information of interest. Dynamic biosonar adjustments have mainly been studied in relation to range to the main target(s) of interest, however, the influence of the context in which echolocation tasks are solved is largely unknown. Here we test the hypothesis that toothed whales use context-dependent biosonar adjustments. We did this by training two captive harbour porpoises to actively approach the same sound recording target (SoundTrap), while blindfolded and wearing a sound recording tag (DTAG-4), over the same 8 m approach distance in two highly different environments; a PVC-lined pool and a semi-natural net pen in a harbour. We show that the porpoises used significantly longer interclick intervals (ICIs) in the net pen than in the pool except during the buzz phase where the porpoises used slightly shorter ICIs in the net pen. The reverberation level, quantified as the median 128 kHz third-octave level, was more than 10 dB higher in the pool than the net pen. We also demonstrate stronger range-dependent ICI and source level adjustments in the pool compared to the net pen environment. We conclude that context is an important factor to consider in addition to target range in studies of biosonar dynamics, and adds another layer of complexity to understanding toothed whale biosonar operation. Importantly, passive acoustic monitoring (PAM) studies should therefore consider context and species-specific ICI distributions across widely different habitats.

Morphological and molecular identification of gastrointestinal parasites in free-living striped dolphin (Stenella coeruleoalba) of the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea)

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The striped dolphin *Stenella coeruleolba* has been reported to be host of several gastrointestinal parasites as protozoa, nematoda, cestoda, trematoda and acanthocephalan, some of them considered to be highly pathogenic and cause of death for this small odontocetes. Generally, parasitological investigations on the gastrointestinal parasites have been carried out on stranded and dead dolphins and only occasionally the necropsy provided information on death cause. Conversely, data on gastrointestinal parasites in free-living dolphins are still limited due to the difficulty in collecting samples and the cost effort in performing experimental studies. The present study provides results on the gastrointestinal parasites fauna infecting *S. coeruleolba* free living in the Gulf of Taranto, by using non minimally invasive methods to collect fecal samples. Standardized vessel-based surveys targeting the striped dolphins was carried out from September 2018 in the study area, and

GPS position, depth (m) and number of observed striped dolphins were recorded during sightings. Each fecal sample was subjected to coprological examinations and molecular techniques in order to identify/characterize the parasites. Analysis revealed that *S. coeruleolba* harboured 3 parasites species (2 protozoa and 1 nematode) with some of them bearing zoonotic and/or pathogenic potential. Although preliminary, this study represents the first parasitological monitoring in free living dolphins within the Mediterranean Sea providing a baseline for studies on dolphin's health as well as a contribution towards the development of effective conservation plan for species in this biogeographic region.

The International Impulsive Noise Register for the Mediterranean Sea Region (INR-MED)

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The QUIETMED project, funded by the EC-DG Environment, aims to enhance cooperation among Member States (MS) in the Mediterranean Sea to implement the Second Cycle of the Marine Directive through: i) promoting a common approach at Mediterranean level to update GES and Environmental targets related to Descriptor 11 on underwater noise; ii) development of methodological aspects for the implementation of ambient noise monitoring programs; iii) development of an impulsive noise joint monitoring program based on a common register, including gathering and processing available data on underwater noise. The project was developed by a consortium composed of 10 entities coordinated by CTN. It ended in December 2018, after 24 months of duration.

In this framework, a common register for the Mediterranean basin for the monitoring of impulsive noise was developed in line with the European Commission Decision 2017/848 and following technical recommendations from the TG-Noise. The conception is based on the first demonstration tool developed by ACCOBAMS in 2016. The development also took advantage of similar initiatives on Descriptor 11 in European seas (OSPAR, HELCOM and ICES).

This Impulsive Noise Register in the Mediterranean region (INR-MED) facilitates the assessment of pressure levels for D11 in the process relative to the MSFD or to the Ecosystem Approach led by Barcelona Convention (for EU and non-EU Mediterranean Countries). Indeed, once data are uploaded, the reported noise events are displayed in a map interface and calculation of Criterion 1 of D11 (Anthropogenic impulsive sound in water) is automatically provided, facilitating the interpretation.

For moving forward with future combined risk and impact analysis, the project QUIETMED2, also funded by the DG Environment, will facilitate the assessment through the establishment of a link between the pressure and the associated environmental risk.

Interactions between cetaceans and purse seine fisheries in the Madeira archipelago (NE Atlantic)

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The waters off Madeira archipelago present a large diversity of marine mammals. Of the 38 species that can be encountered in the Atlantic Ocean, 29 have been recorded here. Despite this great abundance, this study provides the first assessment of the range and impact of cetacean interactions with fisheries for this region. One observer collected data aboard three artisanal purse seine fishing vessels small targeting small pelagic fish species, covering 100% of the fleet, during 13 months. Data collected covered cetacean sightings, fishing event parameters and interactions. Thirty-six sightings were registered on 21 trips, from a total of 72 trips monitored. The common bottlenose dolphin (Tursiops truncatus) was the main cetacean species sighted and seen interacting, followed by the short-beaked common dolphin (Delphinus delphis). From the several variables analysed, only the association of sardine (Sardina pilchardus) total catch biomass and cetacean presence was found to be statistically significant (P value = 0.0333) . In Madeira, sardines have low commercial value, thus there is no pressure from fishermen to take action or to implement measures in order to decrease this interaction. However, some negative reactions, including one by-catch event with mortality, were observed, suggesting that mitigation measures may be needed to protect cetaceans. The fact that all the fishing trips occurred at night, with limited

visibility, made the correct identification of cetacean species difficult, and a relatively low percentage of trips was surveyed. This might have influenced the data analysis and conclusions towards good local stock availability, and little or no competition between fishermen and top predators. These results should be regarded with caution as further studies covering more trips and other types of fishery should be undertaken to lead to a more complete assessment of the range and impact of fisheries on cetaceans, in this important oceanic region.

Subarctic winter whales: An overwintering strategy of humpback whales in Icelandic waters.

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Humpback whales (*Megaptera novaeangliae*) were near depletion during the mid-20th century, but for the last two decades they have been recovering rapidly, particularly in polar regions for the last few years. The humpback is a migrating baleen whale whose behaviour is believed to be largely discrete between their winter breeding and summer feeding grounds. Recent research on the migration behaviour of humpbacks in the North Atlantic has shown a delayed winter migration and even overwintering of humpbacks in the subarctic. Recent findings by the author showed how males engage in active singing (a male breeding display) during their reported breeding season in the subarctic, indicating a trade-off between growth and reproduction on a high latitude feeding ground; a strategy which may have assisted these populations' recovery.

The aim of this study is to investigate the occurrence, habitat use, sex ratio and physical state of humpback whales in an Icelandic subarctic feeding ground during the breeding season (January–March) in comparison to the more traditional May–October feeding season. The physical state observed is sexual receptivity, based on sex hormone levels (testosterone, oestradiol and progesterone), and stress based on cortisol levels. Such measurements will allow for an investigation of mating opportunities in the subarctic, pregnancy rate and whether humpbacks experience more stress during the subarctic winter months compared to other seasons. Such information provides insight into the trade-off strategy between overwintering and migrating. The biopsy samples are collected from free roaming humpback whales during the winter (November-February), late spring (April-May), late summer (August) and fall (October). The preliminary results from the first year, i.e. 2018-2019, of a three years study will be presented. The findings could provide a new global perspective of the life history dynamics of this species and their possible response to the rapidly changing climate of the Polar Regions.

Long-term mom/calf associations in rough-toothed dolphins (Steno bredanensis) off the island of Hawai'i: Evidence of a stable matrilineal social structure in a deep-water dolphin?

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Documenting long-term mother/calf associations in cetaceans is often challenging due to the inconspicuous nature of calves. For rough-toothed dolphins however, individuals can be identified using pigmentation patterns visible from birth, allowing for assessing the associations of calves. Using photo-identification data from Hawai'i Island (2003-2018), associations between moms (n=5) and their calves (n=16) were assessed for pairs initially seen in close, constant association and demonstrating synchronous surfacing. Mothers selected were first sighted with calves in 2003/2004, allowing sufficient time to document calf association. Mothers were re-sighted over periods of 4.0-13.7 years (median=11.5). The number of calves per mom ranged from 3-4 (median=3) and calves remained associated up to 9.9 years (median=4.2). Older calves typically remained in association with the mother, occasionally into adulthood, even after new calves were observed, often traveling with the new calf between them. In fact, three of the moms were seen traveling with three different calves, with older calves either surfacing on the fringe of the group or with new associates. All offspring considered sub-adults or younger (n=9) when last sighted (with the exception of one juvenile not re-sighted past 2006 and assumed to have died) remained with the mother for the duration of the study. One adult male remained with the mother for 7.6 years and either left following arrival of a new calf, or died, and one presumed adult female was last sighted

with the mom two years after reaching maturity. Inter-calf intervals, estimated using the date each new calf was first observed, ranged from 3.7-5.0 years; median=3.8, n=6. Despite sample size limitations, this study provides evidence of long-term associations between mothers and calves, suggesting that if dispersal occurs, it is likely at attainment of sexual maturity. More research is needed to determine whether calves eventually disperse or remain in the natal group for life.

Impacts of bridge construction on the Indo-Pacific humpback dolphins (Sousa chinensis) in Hong Kong's waters

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Coastal development is a major threat to the Indo-Pacific humpback dolphins that inhabit Hong Kong's waters. Since 2012, the impacts on the local dolphins caused by the construction of an artificial island and extensive pier structure for several connecting bridges to the artificial island, were revealed by line-transect boat-based surveys, individual photo-identification work and shore-based theodolite tracking. This development project is part of an expansive bridge alignment of the Hong Kong-Zhuhai-Macau Bridge, which is the world's longest sea-crossing bridge connecting three major cities across the Pearl River Estuary, and was undertaken over dolphin habitat around Lantau Island. Line-transect data revealed a dramatic decline in dolphin abundance in northeast Lantau (from 11 in 2011 to 0 in 2018) where the artificial island is situated and also in nearby northwest Lantau (from 39 in 2011 to 6 in 2018). Dolphin densities calculated in a grid system indicated consistently lower dolphin usage in the west Lantau area that overlapped with the bridge alignment while their habitat use became much more confined in north Lantau. Furthermore, individuals' ranges have shifted from north Lantau to west Lantau since the construction commenced. There was also a marked decline in individual movements between northwest and west Lantau through what is believed to be an important traveling corridor for the dolphins and which may now be obstructed by the physical presence of bridge piers. Even though a series of mitigation measures has been adopted during the bridge construction, dolphins were evidently displaced from their once prime habitat (in north Lantau). Given the decreasing trend in dolphin abundance and the ever-increasing threats in the waters surrounding Lantau Island, other conservation measures are urgently needed because the current mitigation actions taken do not appear to be effective at stopping the continuing decline in dolphin numbers using Hong Kong's waters.

Towards ecologically-based management for recreational whale watching.

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Current guidelines for recreational whale watching have little scientific foundation and are largely used because they provide an enforceable regulatory procedure. In light of the growth of cetacean-based tourism and the increase in the breadth and depth of research, we advocate for a stronger ecological and life history grounding to enhance the efficacy of these codes of conduct in reducing whale disturbance. We provide four areas for consideration to refine whale watching management: adaptation to the ecological setting of whale aggregations; quantification of acoustic disturbance by vessels and aircraft; the exclusion of sensitive species, populations, or individuals at critical life stages from the tourism resource base; and the need to assess the cumulative effects of stressors on whales. In each case we draw on examples from our long-term research site on the west coast of Vancouver Island, where foraging gray whales (*Eschrichtius robustus*) are the focal species of tourist activities, but believe these elements are broadly applicable to other species. We suggest mitigation measures such as 'quiet zones', and time-area restrictions on viewing, including more stringent restrictions on encounter lengths, approach distance, and the viewing of animals most sensitive to human-derived stressors.

Kogia echolocation click source parameters measured with a deep water autonomous vertical array

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Dwarf (*Kogia sima*) and pygmy (*Kogia breviceps*) sperm whales are small toothed whales that employ narrow band high frequency (NBHF) clicks for echolocation. Such NBHF clicks are normally found in small, shallow-water toothed whales, such as porpoises, that produce clicks at ~125 kHz. These high frequency clicks are subject to high levels of acoustic absorption and are in keeping with porpoises' short-range echolocation. Here we sought to address the problem of how the little studied Kogia, as deep-diving toothed whales, can find food with NBHF clicks in the deep. Specifically, we tested the hypotheses that Kogia use NBHF clicks with longer inter-click intervals (ICIs), higher directionality, and higher source levels (SLs) compared to shallow water NBHF species. We did this by deploying an autonomous deep-water vertical hydrophone array of 7 synchronized SoundTraps at 576 kHz, for 74.6 hours over 18 deployments in May-June 2018 in the Bahamas, where no other NBHF species are present. Depth/tilt sensors (Star-Oddi) next to the peripheral hydrophones measured array straightness and allowed for calculations of localisation errors arising from tilt. NBHF clicks were detected, classified, and localised (n=828), with 276 clicks deemed on-axis. Based on the calculated locations of clicking Kogia and known positions of each hydrophone, the apparent SL and half-power beamwidth were quantified. Apparent SLs (up to 197 dB re 1μPa_{p-p}) with a peak frequency of 129 kHz mean that Kogia could use their biosonar to inspect out to twice as far as porpoises, assuming the same prey target strength. This range agrees with the mode of their ICIs (245 ms). Their half-power (-3 dB) beamwidth of <10° confirmed our hypothesis of their narrow acoustic field of view. Thus, Kogia use a directional long-range echolocation system with high SLs to compensate for the considerable absorption losses of their NBHF clicks while hunting.

Epigenetic effects of environmental contaminants on the skin of the fin whale (Balenoptera physalus) in the Mediterranean basin.

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The phenotypic plasticity of many organisms is mediated in part by epigenetics, the heritable changes in gene activity that occur without any alterations to DNA sequence. A major mechanism is the DNA methylation (DNAm). Hypo- and hypermethylation are generalized responses to control gene expression but recent studies have demonstrated that classes of contaminants could mark specific DNAm signatures, therefore be used to assess prior environmental exposure.

We sampled skin and blubber from 6 fin whale (*Balenoptera physalus*) individuals living in the northern Mediterranean Sea. Blubber was analyzed for Organochlorines levels while genomic DNA extracted from the skin of the animals with the lowest (mean value = 19 µg/g lipid basis, l.b.) (group 1, n=3) and the highest (mean value = 53 µg/g l.b.) (group 2, n=3) levels of contaminants were used for DNAm profiling through reduced representation bisulfite sequencing (RRBS).

We tested the hypothesis that the differences in the methylation patterns observed comparing the 2 groups are linked to environmental contaminant exposure and load in the whale tissues.

While pronounced variations in CHH and CHG methylation (where H is any base except G) were not observed, the CpGs showed 32683 differentially methylated Cs in promoters and/or exon/intron regions of genes ($p < 0.05$, mean coverage = 8.5), accounting for 13% of the whole set.

Gene Ontology indicated that DNAm affected genes dealt with cell differentiation and function in nervous, endocrine, immune, circulatory and muscular systems.

qPCR on a larger set of skin samples with known contamination loads correlated differential expression of selected genes with DNAm changes.

Eco-epigenetics have extraordinary potential to advance our understanding of biological responses to environmental challenges, and yield sensitive tools for pollution biomonitoring and ecotoxicity assessment.

Introducing the Risso's dolphins of the Isle of Man

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The Isle of Man is a small island situated in the middle of the shallow Irish Sea. There have been no dedicated publications addressing cetacean presence in Manx waters, only brief mention in other British Isles studies. Manx waters are one of the few places in the British Isles where Risso's dolphins (*Grampus griseus*) are seen regularly throughout the summer months very close to the coast. Manx Whale and Dolphin Watch have collected over a decade of public sightings, boat based, land based, and photo-identification data for Manx cetaceans including the Risso's dolphin. Presented here is an overview of these data to introduce the Isle of Man as what appears to be an important habitat for Risso's dolphins in this part of the world. These data highlight an area of consistent summer seasonal use by Risso's dolphins with good sighting numbers, and photo-ID catalogue size and re-sightings rates comparable to other published British Isle 'hot-spots' such as those in Wales and the Scottish Hebrides as well as regional photo-ID matches. Compared to regions such as the Azores, the British Isles shows lower re-sighting rates of Risso's dolphins, perhaps suggesting larger home ranges and a wider use of the region as a whole. As a central point in this region the Isle of Man may serve as an important 'mixing' location for Risso's dolphins from the north and the south which will only be evidenced by a greater focus on consistent photo-identification data and a strong collaboration between parties studying this fascinating species around this region.

Integrating demography and genetics to guide conservation: A case study of coastal dolphin populations.

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The viability of populations depends on metapopulation dynamics: the combination of reproduction and mortality within populations, as well as dispersal between populations. Population viability is also dependent on genetic diversity, which is essential for populations to adapt to environmental change. This study focuses on an Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) population in coastal waters near Bunbury, Western Australia. Population viability analysis on this population suggested that recent reproductive output was not sufficient to offset mortality. Migrants from adjacent populations might make up this deficit, so that Bunbury would act as a "sink," or net recipient population. We investigated historical dispersal in and out of Bunbury, using microsatellites and mitochondrial DNA of 193 dolphins across five study locations along the southwestern Australian coastline. Additionally, we assessed adaptive genetic diversity of the major histocompatibility complex (MHC) in the Bunbury population and compared that to a stable conspecific population. Our results indicated limited gene flow between Bunbury and adjacent populations. The data also indicated a net-dispersal from Bunbury to neighboring populations, with microsatellites showing that more than twice as many individuals per generation dispersed out of Bunbury than into Bunbury. Therefore, in historic times, Bunbury appears to have acted as a source population, supporting nearby populations. In combination with the prior finding that Bunbury is currently not producing surplus offspring to support adjacent populations, this potential reversal of source-sink dynamics, may have serious conservation implications for Bunbury and other populations nearby. The analysis of MHC genetic variation revealed that Bunbury exhibited lower MHC diversity compared to the stable population. The comparatively low MHC genetic variability may limit the Bunbury populations' adaptive potential to environmental change and could thus negatively influence population viability.

From birth to death: Life history strategies in wild bottlenose dolphins, Shark Bay, Australia.

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Longitudinal study is invaluable for understanding life history strategies of wild animals. Here, we provide the first overview of life history strategies for a wild cetacean, studied from birth to death, including key tradeoffs for each developmental period. The calf period is characterized by relatively high mortality (~34% by age 3, N=795), intensive maternal investment (weaning 4.0 yrs., range=2.6-8.6), and development of basic hunting tactics and social bonds. Maternal socio-ecological strategies set the stage for their offspring, particularly daughters, with lifespan stability of some hunting and social behaviors. Although sex differences emerge in infancy, with females more focused on hunting, and males, on their social lives, this pattern becomes more exaggerated in the juvenile period. Mortality risk is still elevated (21% between the ages of 4-10, N=508), but higher for males than females, arguably because of male social competition. Females, closer to their mother's network, are focused on foraging tactics. At the onset of female reproduction (mean age of first birth=12.8 (SD=1.6), female mortality risk increases. Costs of reproduction are high, not only because of the energetic costs of pregnancy and lactation, but also allied sexual coercion. To date, females who failed to produce a surviving calf before age 25, never did (23% of 163 females with complete histories). Male mortality matches females again when they reach their late teens, when mating competition is high and males achieve their first paternities. Median lifespan is 34.5 for both sexes (N=665) if they survive the juvenile period, but some of the oldest individuals in our population are males (early 50s). While reproduction is costly to survival for both sexes, social bonds are also important. Loss of social position (closeness centrality) contributes mortality for males and females. The sex-specific selection pressures shaping life history strategies in dolphins are discussed.

Marine protected areas dedicated to marine mammals in the Caribbean

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The Caribbean Sea is a hot spot for marine mammals biodiversity with over 31 species suspected among the 80 identified worldwide. However the low coverage of marine protected areas of national and international waters in this region (well below the 10% of the Aichi Biodiversity Target of 2020) makes their conservation all the more difficult. To resolve this issue, several countries have created marine mammals' sanctuaries covering their entire EEZ or at least large zones of it.

Along with national and international policies dedicated to marine mammals, this may be one the best way to ensure protected areas large enough to encompass marine mammals' high mobility. However some of these sanctuaries aren't recognized by the IUCN's world database on protected areas and most of them don't have any management plan or enforcement in place.

In the direct line of the Sistership Sanctuary Network initiated by the Stellwagen Bank National Marine Sanctuary (NOAA), the European Project CARI'MAM, led by the Agoa Sanctuary (French Biodiversity Agency), aims to form a network of marine protected areas dedicated to marine mammal conservation in the Wider Caribbean region and beyond. Among the action led trough the project, emphasis is put on capacity-building for managers and development of common management tools. The Transatlantic MPA Network also initiated a twinning program specifically dedicated to marine mammals throughout the Ocean, which led during the last year to the development of tools specifically designed to answer marine mammals' management.

Together, these projects develop new opportunities to enhance the conservation of marine mammals in the Caribbean and their inclusion in national and international policies.

Cetacean-habitat relationships are poorly transferable across the North Atlantic Ocean

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Species distribution models rely on the strong, often untested, hypothesis that species-habitat relationships are transferable across geographic space. As large-scale conservation needs increasingly necessitate building species distribution models from data assembled from

multiple locations, it is critical to assess how species-habitat relationships vary across space. Our objective was to test if relationships between cetacean distributions and habitat covariates are transferable across the North Atlantic. We studied 12 cetacean taxa that occur on both sides of the Atlantic and 3 covariates commonly used in cetacean distribution models (depth, sea surface temperature and primary productivity). We related cetacean presence on survey transects to each habitat covariate using 2 types of models: (1) global models that assumed relationships are similar on both sides of the Atlantic and (2) region-specific models that assumed relationships vary between the two regions. Ten of the 12 taxa showed substantial differences in their depth relationship using the region-specific model (e.g., fin whale's presence decreasing with depth in the west but increasing in the east), while only beaked whales and bottlenose dolphin showed non-significant differences between regions. Ten taxa showed substantial differences in their sea surface temperature relationship (e.g., sei whale's presence peaking at 12.7°C in the west and 18.2°C in the east), while sperm whale and Atlantic white-sided dolphin showed non-significant differences between regions. Eight taxa showed important differences in their relationship with primary productivity between regions, e.g., Risso's dolphin, whose presence peaked around 1000 $mgC.m^{-2}.d^{-1}$ in the west and 1600 $mgC.m^{-2}.d^{-1}$ in the east. In contrast, beaked whales, pilot whales, Atlantic white-sided dolphin and bottlenose dolphin showed non-significant differences in their primary productivity relationship between regions. Our results suggest that cetacean-habitat relationships are poorly transferable across the North Atlantic and stress the need to consider between-region variability when modeling cetacean distributions as a function of habitat across ocean basins.

Social structure in a resident population of bottlenose dolphins (Tursiops truncatus) in NW Spain (Galicia)

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Social network analysis is important for studying the evolution of social systems. The aim of this study is to describe the social structure of a resident population of common bottlenose dolphins (*Tursiops truncatus*). Data were collected between January and June 2017 onboard a research vessel in the Ria de Arousa (Galicia, North West of Spain). Dolphins were identified by the natural marks present on their dorsal fin with photo-identification analysis. The strength of the associations was measured using the Half Weight Index (HWI). Social structure and network analysis were carried out with SOCPROG. 111 sigthings were recorded and 118 individuals were identified. Analysis was restrictred to adult marked individuals observed on more than six differents days (n = 42 dolphins). On average, each individual was seen 12 times (se = 0.65). Permutation analysis showed preferred association between individuals. The average HWI was 0.29 (sd = 0.11), the sum HWI was 12.84 (sd = 4.53), and the max HWI was 0.65 (sd = 0.12). The affinity of this population was 12.86 (sd = 2.16), the strenght was 11.84 (sd = 4.53), the eigenvector centrality was 0.14 (sd = 0.06), the reach was 160.23 (sd = 68.66), and the clustering coefficient was 0.44 (sd = 0.07). Temporal analysis demonstrated that dolphins showed rapid dissociations and preferred companions. Modularity analysis reported a population divided in 5 different social groups. These findings report a social structure characterized by fission-fusion dynamics with preferred associations between individuals. Further studies are needed to understand the potential factors (e.g., sex and behaviour) determining the observed differences in association between individuals.

Microbial diversity in the intestine of stranded southern right whale calves (Eubalaena australis)

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Over 725 southern right whale (*Eubalaena australis*) calves died at Península Valdés, Argentina during 2003-2018. No such mortality has occurred at other right whale calving grounds. While pathogenic microbes are often suggested to cause mortality in cetaceans, to date there is no evidence supporting bacterial infections as a leading cause of right whale calf deaths in Argentina. In this study we aimed to identify the bacterial community in the guts of stranded right whale calves and explore whether some of those bacteria were pathogenic and potentially linked to calf mortality. We used high-throughput sequencing and culture methods to characterize the bacterial communities from the small and large intestine of stranded calves (n=44) that died in 2005-2010. We found 108 bacterial genera, most identified as Firmicutes or Bacteroidetes, and 9 genera that have been previously implicated in diseases of marine mammals including *Mycoplasma*, *Streptococcus*, *Erysipelothrix* and *Clostridium*. *Clostridium perfringens* was present in all samples. Moreover, all *C. perfringens* isolates (n=38) were positive for alpha, 50% for beta 2 (n=19) and 47% for enterotoxin (CPE) genes (n=18). *Clostridium perfringens* is associated with food-poisoning and gastrointestinal diseases in humans and possibly other animals. The prevalence of the cpe gene found in the Valdés calves is unusually high compared with other mammals. However, insufficient histologic evidence of gastrointestinal lesions in the gut of stranded calves (possibly masked by autolysis), and absence of enterotoxins, precludes conclusions about the role of *C. perfringens* in calf deaths. This is the first reported characterization of the microbial community that lives within the intestines of baleen whale calves and one of the few to study potential pathogenic bacteria in stranded whale carcasses.

A new, multidisciplinary approach to monitor the health status of free-living fin (Balaenoptera physalus) and sperm (Physeter macrocephalus) whales in the Pelagos Sanctuary, Corsican-Ligurian-Provençal basin.

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Fin and sperm whale Mediterranean populations are classified respectively as vulnerable and endangered in the International Union for Conservation of Nature Red List and potentially threatened by both infectious diseases and anthropogenic factors. Parasites, bacteria, as well as organic and inorganic pollutants, are considered among the main causes of whale's death or factors predisposing them to other pathologies. To date, most of the investigations on these species have been carried out on stranded and dead whales and performed by necropsy, occasionally providing information on the death causes. Nowadays, data on health status in free-living whales are limited, mainly due to both the difficulty and the high costs of sampling. In order to get information on the health status of fin and sperm whales living in the Pelagos Sanctuary, a preliminary, multidisciplinary study was carried out analysing three faecal samples (2 samples from fin whales and 1 sample from sperm whale) collected with a non-invasive sampling method in the framework of a 30-years long research project on the ecology of these two populations. Each faecal sample underwent parasitological, microbiological and chemical analysis. Results revealed that fin and sperm whales harbour *Blastocystis* sp., a protozoan parasite with an anthropozoonotic potential, which was never recorded before in these species. Furthermore, a more diverse bacterial community and a higher concentration of heavy metals (*i.e.,* As, Co, Hg) were found in the sperm whale sample compared to fin whale ones, while the concentration of 16 EPA PAHs and 21 PCBs was <2 ppb in all tested samples. This preliminary study represents the first report of a multidisciplinary approach in live whales investigation, and may provide a baseline for both future monitoring studies on the relationships between health status and anthropogenic pressure, and the development of effective conservation plan for these species in the Mediterranean Sea.

Improving evaluation of cetacean interactions with fisheries in a stakeholder participatory context: A running example in Southern Portugal (Algarve).

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The Algarve (southern Portugal) is an important fishing region in Portugal, with a high potential for cetacean-fishery interactions. Increasing interactions between fisheries and marine protected species (e.g. cetaceans) are a reality and occur worldwide in many forms. The negative aspects of these interactions for both fishermen (e.g. loss of

catch through depredation or gear damage) and for the animals (e.g. incidental capture leading in most cases to death) are of most concern. The only works available regarding this subject for the region, indicate that several cetacean species interact with many coastal fisheries in the area, with the purse seine fishery best documented. However, work is still needed to evaluate the level of the events and work towards mitigation strategies. We used face to face interviews (n~200) along the Algarve coast covering the most important fishing ports (n=11) to identify areas, fishing gears and cetacean species of most concern. We found that interactions occur mainly along the whole Algarve coast between the purse seine and common dolphins, *Delphinus delphis* with occasional bycatch. On the other hand, for set net fisheries (gill or trammel nets), interactions are frequent with bottlenose dolphins, *Tursiops truncatus,* and mainly in the leeward (eastern Algarve) side of the coast, where damage of catch and fishing gear were highly reported and bycatch levels are low. Minimizing cetacean–fishery interactions requires the implementation of case-specific management strategies with the active participation of fishers. Ongoing work using a participatory multi-actor approach involving various stakeholders is taking place to find the best mitigation approaches as also in a way to obtain better results in local marine management and conservation.

Morphological and molecular characterization of Pennella sp. (Copepoda: Pennellidae) isolated in sperm and fin whales from the Mediterranean Sea.

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Pennella Oken, 1816 is a genus of mesoparasitic copepods, infecting cephalopods, teleost fishes and marine mammals. Two species are mainly reported in fish (P. instructa and P. filosa), while P. balaenopterae is the species described in cetaceans. The aim of this report is to characterize morphologically and molecularly adult and immature stages of Pennella sp. collected in sperm and fin whale stranded along Italian coastlines. Specimens of Pennella sp. were collected from skin-blubber of three sperm whale (Physeter macrocephalus) and six fin whale (Balaenoptera physalus) stranded along the Apulian, Sardinian and Tuscan coasts between 2008 and 2015. The samples were preserved in 70% ethanol and studied by stereomicroscopy, microscopy and environmental scanning electron microscope. The adult copepods (from sperm whale and fin whale) were identified as P. balaenopterae (Abaunza et al., Crustacean 74: 193-210, 2001), while the immature copepods were referred to Pennella filosa, according to the morphological features reported by Thompson (1905, Biol Bull 8 (5): 296-307). Portions of adult and immature specimens were also submitted to molecular analyses by a PCR, amplifying the mtDNA cox1 gene (using the primers LCO1490 and HCO2198 (Folmer et al., 1994; Mol Mar Biol Biotechnol. 3(5): 294–299)). The sequences were compared with those present in GenBank and previously obtained from specimens of P. filosa (from bluefin tuna) and P. instructa (from swordfish). Alignment of the sequences was performed using BioEdit and genetic analysis (MP, NJ) by MEGA6.0 was performed. The preliminary results of this study indicate a genetic similarity among all the different Pennella spp., suggesting that they could be morphotypes adapted to different hosts. This result would support the hypothesis that P. balaenopterae and P. filosa are conspecific (Fernandez et al., Dis Aquat Org, 128:249-258, 2018). Hereafter, the use of other markers will be also useful to clarify this aspect.

Vertebral morphology in partially sympatric dolphin species: A 3D approach.

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In cetaceans, body flexibility is associated with swimming speed and foraging behavior. Greater

flexibility is associated with increased maneuverability. One factor affecting flexibility is the structure and interference of the vertebrae. We studied vertebral morphology in four closely related and partially sympatric dolphin species from the Southern Hemisphere: Commerson's dolphin (*Cephalorhynchus commersonii*), Peale's dolphin (*Lagenorhynchus australis*), dusky dolphin (*Lagenorhynchus obscurus*) and hourglass dolphin (*Lagenorhynchus cruciger*). The former two, are usually referred to as coastal. They are associated with complex habitats and foraging strategies that require greater maneuverability, showing plasticity in their prey preference. The latter two are cooperative feeders on pelagic prey with long distance displacements according to prey availability. We employed 3D geometric morphometrics to analyze differences in vertebral morphology and relate them with the preferred habitats and habits. We used a Microscribe G2X to obtain five original landmark configurations with 28 to 41 landmarks, depending on the functional region under analysis. We performed multivariate analyses for comparisons (PCA and CVA). Inferences about the biomechanical significance of the particular morphologies allowed us to establish links between morphology and behavioral patterns. PCA showed there is great differentiation among species along the vertebral column. This was especially evident in the mid area, except for the dusky and hourglass dolphin; that showed no difference in the mid-column. PCA results were confirmed by CVA. Features associated with greater flexibility were observed in species with complex habitats/behaviors whilst cooperative feeder species had features associated with greater stability. In these latter species, mid-column morphologies suggested a mechanical advantage of the swimming muscles. Even though these species are closely related, vertebral morphology is distinctive and it is related to each species foraging strategy and habitat. This reflects high plasticity and highlights the importance of habitat and behavioral complexity in the development of particular adaptations.

Just a miniature larynx? Unique laryngeal anatomy of humpback whale (Megaptera novaeangliae) calves may limit their acoustic production.

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Strandings are dramatic events, but also significant opportunities to collect anatomical data as population monitoring cues. During the 2018 breeding season in Madagascar, two humpback whale calves (*Megaptera novaeangliae*) stranded. Necropsies were conducted on both extracting the larynx from the relatively fresh carcasses. Results were compared to an adult specimen from a 2016 stranding. We investigate anatomical features that could explain the surprising range of low to mid-frequency social calls produced by calves recently discovered. Findings revealed that the calf larynx had the same anatomical structure as an adult larynx, including a laryngeal sac and cartilages (epiglottic, thyroid, cricoid, corniculate, arytenoid). The arytenoids support the U-folds, and appear to generate sound from airflow between lungs and laryngeal sac. However, laryngeal structures showed more flexibility and cartilages had not reached their final thickness traits likely attributed to the calves' early age. The pliability of laryngeal structures may restrict calves to a narrow range of vocalization frequencies. This may be due to an unstable cartilaginous frame that compromises muscle actions. Muscles pulling against weak attachments may cause difficultly producing high frequency sounds. Specific sounds require the U-fold aperture to be held at certain angles (adduction or abduction) against ingressive or egressive airflow, requiring higher muscle tension. Additional muscular energy may be needed to maintain an effective posture of cartilaginous frame. Complete arytenoid adduction or abduction are probably easier to hold compared with intermediate positions. Calves may tire more easily from this muscle strain, perhaps accounting for their narrow vocal production range. Also, we explore new combined and non-invasive techniques to estimate with accuracy early calf age, observing the presence, and settlement spreading of a parasitic barnacle (Coronula) Encouraging preliminary result allowed a age class categorization of the two calves. Confirming this

potential estimation technique, will need further testing on known age specimens.

Lethal interaction of bottlenose dolphins with two other cetacean species in the Western Mediterranean

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Attacks of bottlenose dolphins (*Tursiops truncatus*) to harbour porpoises (*Phocoena phocoena*) resulting in death have been previously reported in different populations around the world but reports of fatal interactions with other larger cetacean species are exceptional. Here we report on ten stripped dolphins (*Stenella coeruleoalba*) and two Risso´s dolphins (*Grampus griseus*) that were found stranded on the Mediterranean coast of Spain and presumably died as a consequence of interactions with bottlenose dolphins. Inference was based on specific rake marks and severe internal lesions of traumatic origin including skull and ribs fractures, brain haemorrhage, haemothorax or haemoabdomen. Presumptive diagnosis was reinforced by comprehensive complementary analysis of collected samples. Complete necropsy, histopathology, microbiology and molecular diagnosis ruled out other causes of death including by-catch. All twelve cases included significant number of identifiable rake marks, with inter-tooth spacing compatible with that display in bottlenose dolphins. Microscopically, the main findings were severe tissue haemorrhages with related secondary changes. Interspecific agonistic interactions between cetaceans are considered as part of the natural behavioural repertoire of species but have been interpreted differently depending on authors. Based on previous evidence drawn from the interactions between bottlenose dolphins and harbour porpoises, we put forward several hypotheses to account of the aggressive interactions observed in the study area, including territoriality, a poor defined behaviour in cetaceans, and/or influence of human activities such as fish farms. These data provide key information for a better understanding of dolphin behaviour and human–wildlife interactions.

Environmental factors driving cetacean distribution off the central Catalan coast

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Several species of cetaceans have been recorded off the Catalan coast. Previous studies and stranding records carried out since the 1970s suggest that cetaceans are present year round in the Northwestern Mediterranean Sea, however, there is a lack of information on cetacean distribution off the central Catalan coast. Understanding species distribution has proven to be a crucial factor in developing effective conservation measures and management plans. The present work aims to assess the factors that influence cetacean distribution off the central Catalan coast by using data collected as part of 2 different projects conducted by Associació Cetàcea since 2013. Data were collected year round in two periods (march 2013 – June 2014 and April 2016 – December 2018) during 79 days at sea, covering 2955 nautical miles. In total, 122 sightings of 6 different species, including fin whales (*Balaenoptera physalus*), bottlenose dolphins (*Tursiops truncatus*), striped dolphins (*Stenella coeruleoalba*), Risso's dolphins (*Grampus griseus*), sperm whales (*Physeter macrocephalus*) and common dolphins (*Delphinus delphis*) were recorded during that period. A presence/absence method was used to assess the distribution of the different species and to link it to a series of geographical and environmental factors. Preliminary results show that species distribution might be highly influenced by the characteristics of the seafloor, namely depth, slope, aspect and by the presence of geographical accidents such as underwater canyons. The study provides a better understanding of the cetacean distribution off the central Catalan coast, an area included in a recently developed Specially Protected Area of Mediterranean Importance, and will contribute to the development of effective conservation

measures as a valuable baseline information on cetacean distribution.

Evidence for fission-fusion grouping pattern in narwhal inferred from telemetry data

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Cetaceans are social animals that live in groups, which has important consequences for the fitness of individuals. Groups vary in stability from permanent groups that last for life, to fission-fusion groups that may only last for a few hours. During the ice-free season, narwhals form mixed sex and age-class clusters of up to 25 narwhals within proximity to one another. These small clusters are part of large herds of several hundred individuals. Although the snap-shot composition of narwhal clusters (i.e. sex and age-class composition) has been examined, the stability of narwhal clusters over time remains unknown. We equipped seven pairs of narwhals from seven different clusters with satellite transmitters to investigate the stability of clusters. During the ice-free season (August - October), pairs of narwhals spent on average 16.7 % (range: 1.1 to 44.4%) of their time within proximity to one another (5km). One pair of narwhals split at least 5 times and spent up to 12 days and 200 km apart before coming back together during the 80 day they were tagged. Another pair of narwhals spent more than a month up to 500 km apart during the fall migration and reunited on their wintering grounds in Davis Strait. This study suggests that narwhals show characteristics of a fission-fusion society in which group formation is highly dynamic, and group size and composition change frequently.

Intraspecific variation in social structure in female bottlenose dolphins is driven by a combination of ecological, genetic, and cultural aspects

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The complexity of dolphin social structure can only be compared to that found in primates including humans. Although many dolphin populations are characterized by a fission fusion system, preferred associations between individuals can lead to community structure within populations. While male bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Western Australia, form persisting social bonds within multi-level alliances, drivers of association in female bottlenose dolphins are not well understood. We investigated association patterns and community structure of female Indo-Pacific Bottlenose Dolphins in the western part of the bay. We assessed the role of kinship, habitat similarity, and shared foraging techniques (culturally transmitted tool use) on female association patterns. Permutation-based Mantel tests suggested that association indices were best explained by individuals sharing the same habitat ($p < 0.001$), the same mtDNA haplotype ($p < 0.01$), and the same foraging technique ($p < 0.001$), suggesting the presence of homophily. We also implemented three different community detection algorithms to assess the underlying female community structure in Western Shark Bay. All three algorithms identified habitat to be an important driver of community structure. Our results indicate that intraspecific variation in social structure in this bottlenose dolphin population is driven by a complex combination of both ecological and genetic aspects, but that also cultural processes appear to shape dolphin social structure, similarly to what has been described in humans.

Cetaceans as a potential indicators of micro- and macroplastic impact in the marine environment: Trend topic and emerging gaps.

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How can 5 mm plastic debris (microplastics) affect filter feeder baleen whales? How can kilograms of plastic debris affect sperm whales? Here, we report the scientific evidence and the emerging gaps of the interaction between the charismatic megafauna (filter feeder baleen whales and deep divers) and micro- and macroplastics studying their impact and their related toxicological effects. We also propose these species as candidate indicators for micro- and macro-plastic pollution, respectively, at global scale. Regarding the interaction between whales and microplastics the first warning was reported for Mediterranean fin whales (*Balaenoptera physalus*) since 2012, and confirmed later (high concentrations of PBTs, plastic additives and specific biomarker responses, detected in skin biopsies) in the same species and for other filter feeders (basking and whale sharks). Filter-feeding megafauna are susceptible to high levels of microplastics ingestion and exposure to associated

toxic compounds due to their feeding strategies and for habitat overlap with microplastic hot spots. For these reasons, this whale species has been proposed as a candidate indicator of microplastics pollution in semi-enclosed basins. On the other hand, deep divers such as the sperm whale and the Cuvier's beaked whale, are exposed to the ingestion of marine litter (ML), including large plastic fragments, due to their feeding in marine canyons. High occurrence of ML (75%) has been reported in Mediterranean sperm whales. This species was recently proposed as a candidate indicator the presence of ML in the Mediterranean (IMAP indicator 24). As these megafauna species are charismatic and iconic indicators that serve as flagship species for marine conservation, this research field became recently a "trend topic". However, several gaps must be resolved, such as the investigations of new plastic tracers in the tissues and the identification (through omics techniques) of the toxicological effects caused to plastic debris ingestion in these species.

The role of sperm whales as benthopelagic predators.

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Sperm whales (*Physeter macrocephalus*) produce powerful clicks that allow them to echolocate prey at long ranges in the darkness of the deep ocean. They use information gleaned by echolocation to choose dynamically the foraging habitat targeted in each dive. At high latitudes they exploit epi-, meso-, and benthopelagic prey with highly variable diving patterns. This contrasts with their stereotyped diving behavior at low latitudes, where whales do not feed on epipelagic prey and maintain a typical maximum dive depth of 600-800 m. These differences have been interpreted as behavioural adaptations to geographical variation in prey resources rather than as sex-driven choice of foraging strategies. Here we aim to uncover how the dependence of benthic resources of sperm whales in low latitudes differ between two areas where this species has genetically distinct populations: the Gulf of Mexico (GOM) and the Mediterranean Sea (Med). We used data gathered with sound and movement recording DTAGs from 16 sperm whales (8 GOM, 8 Med) summing some 117 deep dives in 125 tag-hours. Clicks were identified with a supervised automatic detector and echograms were formed to locate seafloor echoes generated by the clicks. All sperm whales fed within the mesopelagic realm, but approximately 50% of deep dives entered the Benthic Boundary Layer (BBL, 0-200 m altitude above the seafloor). Sperm whales have an important role as top-predators in offshore waters, where they consume a large biomass and contribute to the recirculation of nutrients, and potentially pollutants, from deep to shallow waters. Understanding their trophic ecology and their dependence on different niches is essential for trophic web modeling and to assess the vulnerability of the species to human resource exploitation.

Bottlenose dolphin social sounds during interaction with bottom-trawl fishery in the Mediterranean Sea

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Acoustic communication signals play an important role in mediating different relations in social animals. Bottlenose dolphins (*Tursiops truncatus*) produce whistles as social sounds, and each individual develops its own distinctive signature whistle encoding identity information. We assessed social sounds by bottlenose dolphins while interacting with bottom-trawl fishery in the central Tyrrhenian Sea and in the Sicily Channel (Italy). Both stationary and towed hydrophones were used to collect acoustic data by group of dolphins following trawling vessels to exploit anthropogenic food patches. The frequencies of different whistle types (upsweep, down sweep, concave, convex, flat, modulated), as well as their acoustic parameters (initial, final, maximum and minimum frequencies; number of steps and inflection points; duration) were measured. We found a varied whistle repertoire when animals interact with

fishing vessels, with the presence of some distinctive signature whistles mainly when groups included mother-calf pairs. This kind of whistles help to promote social cohesion among members of the group but are also recorded in stressful situations. This was dramatically evident in a recording collected when a mother-calf pair remained entangled and then died inside the net. Modulated and ascending were the most common whistle types, suggesting they play an important role in the bottlenose dolphin repertoire possibly transmitting specific information among individuals related to this particular feeding strategy. Interacting with trawling vessels requires group coordination and these complex signals may either facilitate individuals to associate with or distinguish those who implement the same foraging tactics.

New urban habitat for humpback whales: Foraging for fish in San Francisco bay.

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Although humpback whale (*Megaptera novaeangliae*) populations in the Eastern North Pacific have mostly recovered, the Mexican Distinct Population Segment (DPS) remains threatened, and mortality from ship strikes and entanglements along the California coast have increased in recent years. Shifts in humpback whale distribution and increased overlap with human activities may exacerbate these threats. Over the past three years, we observed an unprecedented influx of humpback whales into San Francisco Bay, with photo-identification records confirming individuals from the Mexican DPS. Multiple humpback whales entered the bay to feed on northern anchovy (*Engraulis mordax*) during the spring-fall, with a total of 989 sightings by trained observers during April-November of 2016-2018. The three seasons varied in length and intensity, with peak daily numbers in summer reaching 24 whales in the strait west of the Golden Gate Bridge and 15 whales inside the bay east of the bridge. Whales were not resident in the bay throughout their spring-fall feeding seasons. Rather they transited to and from the habitat in a tidally-dependent pattern. We compiled the first photo-identification catalog for San Francisco Bay humpback whales based on comparisons of fluke images. Of 61 cataloged whales, 41 were matched to North Pacific catalogs, including 27 known from their breeding grounds in Mexico. Photo-identification confirmed whales using the bay in successive years. Although arrival of humpback whales in San Francisco Bay may herald recovery of both the Mexican DPS and the bay estuary ecosystem, conservation concerns include potential adverse interactions with vessel traffic in this urban habitat. In addition to disturbance by recreational users making close approaches, the risk of large ship strikes increases as whales enter the narrow, congested Golden Gate Strait. While a relatively new phenomenon, annual feeding by humpback whales may play a significant role in the San Francisco Bay ecosystem.

Surfacing and diving behaviour of snubfin dolphins (Orcaella heinsohni) and implications for visual surveys

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Snubfin dolphins (*Orcaella heinsohni*) are an endemic species found in near-shore habitats throughout northern Australia and southern Papua New Guinea. The IUCN recently listed the species as 'Vulnerable' due to small population sizes, high site-fidelity, limited gene flow, low reproductive rates, and strong overlap with coastal human activities. Consequently, accurate abundance estimates are essential for ongoing assessments of conservation status and population trends, as well as creating informed management plans. Distance sampling is an effective method for estimating dolphin abundance, but is plagued by often unquantified errors related to imperfect detectability (perception bias) and intermittent animal availability (availability bias). This limits the contribution of outcomes to wildlife management plans. However, addressing availability bias requires an understanding of dolphin surfacing behaviour and dive cycles.

In this study, video surveys were conducted from a static, at-sea platform to determine surfacing-diving intervals of snubfin dolphins. The study took place in Roebuck Bay, Western Australia, home to the largest known population of snubfin dolphins. Fieldwork was undertaken in September and October 2014 on-board a permanently-moored

vessel (elevation 7.5 m above the water line). Visual observations were conducted using binoculars and a digital camcorder to record dolphin group size, composition and behaviour. Video footage was reviewed to record surfacing bout duration, breathing rates, and dive duration.

During 46 hours of survey effort, 73 groups were observed. Median group size was one dolphin (maximum eight individuals). Groups were predominantly travelling through the study area (71%), although some foraging (24%) and socialising (5%) behaviours were also recorded. Surface-dive cycles were assessed according to group size and behaviour to evaluate the proportion of time snubfin dolphins are visually available at the surface. Our work provides, to our knowledge, the first estimates of availability bias for Australian snubfin dolphins and will aid on-going conservation plans for this species.

Acoustic tracking reveals at-depth coordination in groups of Blainville's beaked whales

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Blainville's beaked whales (*Mesoplodon densirostris*) are visually elusive, deep-diving cetaceans that roam the deep ocean beyond the continental shelf in small pods of 2-4 animals. Despite their cryptic surface behaviour, the strong, directional echolocation clicks they use to echolocate prey during their frequent deep foraging dives can be detected routinely with passive acoustic monitoring systems. However, acoustically derived population estimates depend crucially on how animals in groups coordinate movement while acoustically active. To investigate this, we used an array of bottom-mounted, cabled hydrophones in Tongue of the Ocean, Bahamas, to track the 3-dimensional movement of 29 beaked whale encounters with 1-3 diving animals. We found that individuals within a group coordinated their foraging behaviour at depth in several ways. Blainville's beaked whales exploited two separate deep foraging layers, but groups of animals almost always exploited the same prey layer, and there was a tendency to only go to the deeper layer when in triplets vs pairs or singletons. While acoustically invisible during the initial portion of the descent, they typically started the vocal portion of their deep dives close together, separated while at depth, and finally converged again before ascending back to the surface. This behaviour is likely driven by a need to balance two conflicting evolutionary pressures: predation risk while at the surface, where being in a silent group is advantageous, and inter-specific competition for prey while at depth, where being too close together is a disadvantage. We discuss the implications of these findings on passive acoustic density estimation.

Insights into cetacean immunology: Do ecological and biological factors make the difference?

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The aim of this study was to evaluate the expression of Major Histocompatibility Complex (MHC) class I chain-related protein A (MICA) in fibroblast cell cultures of cetaceans (skin biopsies of free-ranging specimens and skin samples of freshly stranded cetaceans) by an immunofluorescence technique and to outline possible variations in MICA expression linked to different ecological and biological factors, while also investigating MICA expression after in vitro treatments with different contaminants. Free-ranging or stranded specimens of cetaceans were sampled in the Sea of Cortez (Mexico) (*Balaenoptera edeni, Delphinus capensis* and *Orcinus orca*) and in the Mediterranean Sea (*Balaenoptera physalus, Physeter macrocephalus, Tursiops truncatus* and *Stenella coeruleoalba*). Cell cultures were treated with an OC mixture, flame retardants, PAHs, MeHg and BPA. The 3 species from the Sea of Cortez showed higher basal activity of MICA and lower levels of DDTs and PCBs than the Mediterranean species. A Pearson's linear coefficient equal to -0.59 also confirmed this tendency to have high levels of MICA and low total OC levels. Treatment of cultured fibroblasts with different contaminants mostly resulted in the upregulation of MICA protein expression by at least one treatment dose; downregulation was also found in some species or treatments. MICA alteration indicates a state of stress of the organism and a modification of the immune system's

response and can be proposed as a noninvasive immunological marker that can be measured in skin biopsy samples, thus offering a good alternative to blood measurements.

Whale watching platforms as a tool for the monitoring of the health status of wounded cetacean individuals in the Strait of Gibraltar
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Whale watching is a globally ever-growing activity which under good practice can offer a more sustainable, eco-friendly alternative to massive tourism. Apart from observing animals in their natural habitat, these opportunistic platforms can act as a potential tool for scientific research and environmental education purposes. In the Strait of Gibraltar, whale watching has been developing in the last couple of decades. This area sustains populations of seven resident or transient cetacean species, while it is one of the most important maritime pathways, being the only connection point between the Atlantic Ocean and the Mediterranean Sea. Consequently, the huge volume of commercial maritime traffic, together with the presence of recreational boats, daily fast ferries and intensive fishing activity, represent sources of high anthropogenic pressure for the cetaceans. During the whale watching trips of Turmares Tarifa, scientific data are collected and photographs are taken by the biologists-guides onboard, with the datasets growing in quality and quantity year by year. The analysis of more than 45000 photos since 2012 has revealed injuries and wounds on various sperm whale (*Physeter macrocephalus*), bottlenose dolphin (*Tursiops truncatus*), killer whale (*Orcinus orca*) and pilot whale (*Globicephala melas*) individuals. Such marks can be either attributed to natural causes (e.g. genetics, pathology, interactions with other animals) or to human activities directly (e.g. collisions) or indirectly (e.g. pathogen transfer). Thanks to the continuous data collection during whale watching trips, the evolution of some cases and the health status of the affected individuals have been monitored throughout a timescale varying from months to years. Moreover, the passengers are directly made aware of this problematic situation which forms a large part of the threats cetaceans face in the area. This study highlights the potential contribution of this eco-touristic activity to the conservation policies of cetacean species in the Strait of Gibraltar.

Joining efforts to protect a species? "Expedición Vaquita 2017" a crowdfunding experience.
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Described for the first time in 1958, the vaquita (*Phocena sinus*) has remained virtually anonymous and despite national and international efforts, populations have shown a constant decline from 600 individuals in 1997, to today's estimates of just a few tens, meaning it is currently on the verge of extinction. In 2017 "Explorando la Vida" joined in efforts to protect the vaquita, through the creation of "Expedicion Vaquita 2017" The project's purpose was to improve the conservation of this species by fostering increased public and policy maker's awareness, supporting the running of population studies and cleaning the vaquita habitat from ghost and illegal fishing nets. Throughout the project, which was financed through crowdfunding, we made allies and worked with policymakers, museums, schools, universities, NGO´s, scientist, science disseminators, and others passionate people, who helped in making the vaquita known and promoted the crowdfunding through didactics and ludic fundraising activities. The support of the media and a group of celebrities allowed us to receive donations around the globe. From 17th-22nd August 2017, we cruised the vaquita refuge, especially in the areas that historically had the highest acoustic detection; near "Roca Consag" (31° 07' N, 114° 29' W) aboard the "Narval" the Scientific Vessel from the "Museo de la Ballena y Ciencias del Mar". Main activities were tracking to locate ghost nets, revision, data recovery and reinstallation of hydrophones. Survey efforts involved power binoculars (big eyes), video and photographic documentation and the testing of a new tool; a drone with a thermal camera. A highlight of expedition was the rescue of shipwrecked fishermen three days after their engine failed. The project faced several challenges but sets a precedent showing how people interested in protecting nature can support science through a crowdfunding platform in Mexico.

Heaviside's dolphins (Cephalorhynchus heavisidii) relax acoustic crypsis to increase communication range.
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The costs of predation may exert significant pressure on the mode of communication used by an animal, and many species balance the benefits of communication (e.g. mate attraction) against the potential risk of predation. Four groups of toothed whales have independently evolved narrowband high-frequency (NBHF) echolocation signals. These signals help NBHF species avoid predation through acoustic crypsis by echolocating and communicating at frequencies inaudible to predators such as mammal-eating killer whales. Heaviside's dolphins (*Cephalorhynchus heavisidii*) are thought to exclusively produce NBHF echolocation clicks with a centroid frequency around 125 kHz and little to no energy below 100 kHz. To test this, we recorded wild Heaviside's dolphins in a sheltered bay in Namibia. We demonstrate that Heaviside's dolphins produce a second type of click with lower frequency and broader bandwidth in a frequency range that is audible to killer whales. These clicks are used in burst-pulses and occasional click series but not foraging buzzes. We evaluate three different hypotheses and conclude that the most likely benefit of these clicks is to decrease transmission directivity and increase conspecific communication range. The expected increase in active space depends on background noise but ranges from 2.5 (Wenz Sea State 6) to 5 times (Wenz Sea State 1) the active space of NBHF signals. This dual click strategy therefore allows these social dolphins to maintain acoustic crypsis during navigation and foraging, and to selectively relax their crypsis to facilitate communication with conspecifics.

Do controlled exposure experiments with navy sonar signals elicit a startle response in cetaceans?

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The startle reflex is a response to sounds that reach a level of 70-90 dB (depending on species) above the hearing threshold within milliseconds of the onset of the signal. This reflex, which results in a sudden muscle contraction (flinch), appears to be present in all mammals. A recent study showed that startle responses can occur in stimuli with rise times of up to 100 ms but response magnitude is lower at long rise-times. In contrast to most other sounds, repeated exposure to startling sounds can lead to a sensitization of subsequent avoidance response in most animals. The characteristics of military sonar sounds have the potential to elicit startle response. Here, we investigate whether long-fin pilot whales (n=5), killer whales (n=5), sperm whales (n=4), humpback whales (n=5) and northern bottlenose whales (n=1) show an acoustic startle response to military sonar. These animals were exposed to 1-2kHz sonar stimuli in the 3S controlled exposure experiments between 2006 and 2013. We measured the animals' muscle contractions using triaxial accelerometers and magnetometers recorded with DTAGs during the 1 second window after the start of the stimulus and compared it to movements within a second before and a second after the end of the stimulus as a control. None of the killer whales and long-fin pilot whales here studied appear to show a clear flinch when exposed to stimuli of received levels between 100 and 177 dB re 1 µPa and rise times of 50 ms. This result suggests that the methodology in this study was unable to detect weak flinches above background muscle activity and/or that the test stimuli were unable to elicit the reflex. On-going analysis of the other species will give an indication on the presence or absence of acoustic startle responses and whether they are followed by sensitization or habituation.

Seasonal patterns of the presence of bottlenose dolphin (Tursiops truncatus) and photo id in the South of Iberian Peninsula

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The waters between Algeciras and Gibraltar are well-known for the presence of short-beaked common dolphin (*Delphinus delphis*), but there is little information about others species of dolphins in the area. The Mediterranean subpopulation of bottlenose dolphins (*Tursiops truncatus)* are considered vulnerable species by the IUCN, widely distributed in the Mediterranean Sea and considered resident in the Straits of Gibraltar.

In order to understand if the presence of bottlenose dolphins exhibit seasonal patterns in these waters, a study was carried out from January 2016 until December 2018. Data was gathered on board opportunistic dolphin-watching platforms including photo ID data to be able to identify the individuals. The study compromised of 14,909.4 miles and 2,247 sightings recorded of various species of cetaceans, of these 133 were bottlenose sightings. Encounter rates varied seasonally, revealing a peak in spring. A total of 62 bottlenose dolphin individuals were Photo ID catalogued showing a high proportion of re-sighted individuals.

The groups were located in shallow waters, close to shore, near rivers, inside harbours; as well as in deeper waters of the slope along the submarine canyon located in the middle of the Bay. Preliminary behavioural observations and photographic evidence suggested that bottlenose dolphins use these waters as a feeding ground.

Conservation actions taken to prevent population decline in these species have not been effective to date. The waters between Algeciras and Gibraltar are considered one of the busiest shipping lines in the world, alongside with intense commercial and recreational dolphin watching, as well as commercial and recreational fishing activities.

It is proposed by this study to declare small sized MPA´s to be able to preserve habitat, minimize the risk of by-catch and lower stress from noise or any other disturbance. Enforcement is compulsory together with effective awareness programs and long-term research.

Next generation of animal telemetry, getting more data from marine mammal satellite tags

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Understanding the movements of large marine animals at varying spatial scales is a fundamental need for conservation, management, and research. BOEM and NASA's Advanced Exploration Systems Division are working to accelerate small satellite technology development for the next generation of animal tracking systems. A crowdsourcing ideation challenge and a high altitude balloon experiment were conducted to conceptualize the feasibility of a new telemetry network leveraging small satellites for tracking highly mobile marine megafauna.

Large marine animal tracking is challenging because of the physical constraints of operating in the ocean and the very large distances that animals may travel over small periods of time. Understanding their movements depends upon tools like satellite telemetry. Nearly all satellite telemetry research is transmitted via the Argos system, which is constrained by bandwidth and numbers of satellites. Advances in tag design have improved dramatically, but data transmission from space remains limited and costly. Small satellites, or CubeSats, are revolutionizing the space industry as they significantly reduce the economic costs associated with assembly and launch. Approximately 18,000 CubeSats will be orbiting Earth in the coming decade; leveraging this network could dramatically improve studies of marine animal movements.

NASA's Center of Excellence for Collaborative Innovation convened a global ideation challenge in 2018 to conceptualize an improved telemetry network, the first in a possible series addressing Next Generation Animal Tracking. An expert group consisting of BOEM, NASA, and independent scientists working on telemetry studies developed entry requirements. The challenge had 432 entrants from 32 countries with 36 proposals submitted; two winners were selected. Results of the balloon flight demonstration and submissions to the initial challenge will inform potential future

solutions for open system architecture and software integration.

Differentiation and characteristics of the coastal population units of the humpback whale in Mexico and Central America

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The humpback whales make migrations in all the oceans of the world. Although, the structure of their populations in the North Pacific is complex, it is known that these whales have high fidelity to their feeding areas and that there is very little exchange of individuals among them. A different situation occurs in its winter aggregations, where its fidelity is lower, and the exchange between congregations is frequent, either in the same or in different seasons. Recently, it has been proposed that the humpback whales from the Mexican Pacific belong to at least two population units, one coastal and one offshore. The goal of this study is to clarify the relation between the coastal population with the one from Central America, which is considered endangered by the NOAA. The study is based in order to identify their movements and migratory origins (photo-identification and stable isotopes signatures) and their genetic differences (haplotypic diversity). The photo ids were obtained from our team in Baja California Sur and the collaboration with 5 research groups from the states of, Sinaloa, Nayarit, Colima, Guerrero, Oaxaca. and in Central America. We photo-identified 2,800 different humpback whales from 2013 to 2019. The skin samples were collected in three different locations in the Mexican Pacific: Los Cabos (BCS), Barra de Potosí (Guerrero)., and Puerto Angel, (Oaxaca)., during the winter seasons of 2018 and 2019 and we obtained 165 skin simples. Preliminary results from the photo-identification indicated a strong relationship between the whales from Guerrero, Oaxaca, and Centramérica in the south, and between the whales from Colima, Nayarit, Sinaloa and Baja California Sur in the north. The analysis of the haplotypes and stable isotopes will be presented in December.

Evaluation of gray whale´s body condition in Laguna San Ignacio, BCS, Mexico. during 2018 and 2019 breeding seasons.

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The Eastern North Pacific (ENP) gray whale (*Eschrichtius robustus*) population feeds during the summer around Bering, Chukchi and Beaufort seas, and migrates to winter breeding and calving grounds along the Pacific coast of Baja California, in Mexico. Measurements of the whales' body condition upon arrival at the breeding ground is an indicator of "health and reproductive condition," and indirectly is an indicator of the health of the environment. We photographed and evaluated the body condition of gray whales in Laguna San Ignacio (LSI) in Baja California Sur in 2018 (n=287) and in 2019 (n= 569). Photographs were sorted into two reproductive-sex categories: Females with calves, and Single whales (male or female without a calf). Condition was scored as "good", "fair", or "poor." using a method developed for the Western North Pacific (WNP) gray whales. In LSI the proportion of single whales with "good condition" in 2018 was 43.5%; "fair" 48.3%, and "poor" 8.2% and in 2019 were 22.1%, 54.3%, and 23.6%, respectively. The percent of "poor" body condition in 2019 is the highest observed in LSI. The proportion of females with calves with "good," "fair", and "poor" condition in 2018 were 43.8%, 53.7%, and 2.5%, respectively, and in 2019 were 50.0%, 50.0%, and 0%, respectively. The decrease of single whales in "good" condition during 2018-2019 was not reflected in the percent of females with calves, but may be the result of a small sample of female-calf pairs photo-identified in 2018 (n=86) and 2019

(n=41), compared to the average 226 pairs photo-identified from 2011 to 2017. We conclude that the body condition of all whales were probably similarly affected; however, comparison and correlated with environmental data from the feeding grounds is needed to understand the factors that contribute to the whales' body and reproductive condition.

Hg and Se in tissues of three species of dolphins stranded in the Mediterranean coastline of Southeastern Spain.

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Hg and Se concentrations have been measured in liver, kidney, brain, lung and muscle samples of 5 bottlenose dolphin (*Tursiops truncatus*), 4 common dolphins (*Delphinus delphis*) and 4 Risso´s dolphin (*Grampus griseus*) stranded along the Murcia coast, Southeast Spain, in order to estimate potential risks associated to Hg exposure. Our results were similar to those described for other dolphins in the Mediterranean Sea during the same period of study. Positive correlations between Hg and Se in liver ($r=0.930$, 30 $p<0.001$) and in kidney ($r=0.917$; $p=0.001$) were observed; and the ratio Se/Hg molar was higher than 1 in most cases. These results confirm that Mediterranean Sea is more polluted in than other seas and oceans; however, it seems a decreasing trend in Hg concentration in this ecosystem, which is reflected in cetacean´s tissues. Our results suggest a protective effect of Se against Hg toxicity is occurring in cetaceans. However, we have detected levels of Hg described as responsible liver damage and neurotoxicological effects. So other tools, as biochemical markers, should be included and more studies are needed to evaluate the risk of Hg contaminant exposure in dolphins from Murcia coastline.

Dolphin health monitoring program off the central coast of Veracruz, México.

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The National Park "Sistema Arrecifal Veracruzano" (Veracruz Reef System, VRS), located in the middle of the Gulf of Mexico, is a 65,000 ha Federal Natural Protected Area of biological, ecological, economic, and social importance. However, one of the largest urban development projects in the country is currently being held here: the Veracruz Port expansion. Thus, it is imperative to develop in-depth research using bio-indicators such as dolphins, which can reflect the long term impacts of human activities on marine ecosystems. The main goals of this program are: to assess dolphin spatio-temporal distribution, density, and habitat use; to study behavior, with a focus on trophic ecology; and to determine heavy metal concentrations in dolphins' tissues. From systematic boat-based censuses, distinct techniques were applied to collect ecological (linear transects, *ad libitum*and scan sampling observations, GIS, photo-identification) and physiological data (biopsy samples). From June 2016 to February 2019, three species were recorded: *Tursiops truncatus*,*Stenella attenuata* and *Steno bredanensis*, all showing a coastal distribution (up to 40 m isobath), mainly in the northern zone of the VRS polygon. Two photo-identification catalogues (for *T. truncatus*and *S. bredanensis*) with 154 and 110 individuals, respectively, were built, and more than 50% were resident animals. It was detected that dolphins have habitat preferences for their different activities. Thanks to long-term monitoring pictures, distinct processes and diseases were recorded such as lobomycosis (*Lacazia loboi*) occurrence, and a 3-month healing rate from a shark bite. Physiologically, high concentrations of six heavy metals (Pb, Cr, Fe, Ni, Cu, Zn) were estimated and preliminary results from stable isotope analyses indicated the dolphins' trophic level in the marine food chain. This study constitutes the first effort towards a long-term health monitoring program in the VRS, and provides relevant scientific information for environmental stakeholders in order to promote marine ecosystems conservation.

Residency patterns of Risso's dolphins off São Miguel and inter-island matches with Pico Island (Azores).

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The Risso's dolphin *(Grampus griseus)* is a frequently sighted species in the Azores. Major studies concerning this species have been conducted in the central group of the archipelago, where social structure, residency and nursery

patterns have been investigated for a long term followed population off Pico Island (n=1250).

Here, we aim to identify and analyse the distribution of Risso's dolphins around São Miguel Island, using photos taken during whale watching trips between 2009 and 2018. A photo-ID program to classify dorsal fin marks was developed. The resulting catalogue currently consists of 569 individuals identified from 1124 photographs.

Individuals were classified as "residents" if re-sighted in the study area (south of São Miguel Island) during at least 4 different years with a minimum of 15 sightings. All the other individuals were classified as transient. Accordingly, we identified 557 transient Risso's dolphins and only 12 resident ones in our study area.

This resident pod has been sighted every year of the study except in 2012 and 2013. Since 2014, three new individuals were added to the group. Nowadays (April 2019), this pod is formed by 9 adult females and 3 calves.

Comparing individuals identified off São Miguel with the catalogue from Pico island, we found inter-island matches of at least four different male individuals that were sighted in 2012 off São Miguel. These males were sighted more than 200 times in Pico since 2004 until 2017 but did not appear in 2012. This indicates that presumable "residents" move through the archipelago.

Further research will focus on comparing the catalogues of both islands and analysing habitat conditions for resident vs. transient individuals.

Evaluating long-term change in the risk of parasitism by anisakid spp. nematodes for endangered and threatened marine mammals.

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Intestinal parasites are an understudied but potentially consequential stressor for marine mammal species. These parasites are often found in marine mammals at necropsy. Although they are infrequently identified as a cause of mortality, these parasites could drive cryptic declines in individual fitness – including declines in nutritional status – by acting synergistically with other stressors. Nematodes in the family Anisakidae are intestinal parasites that are ubiquitous throughout the world's oceans and are transmitted to marine mammal hosts through the consumption of fish and cephalopod prey. There is growing evidence that the prevalence of these parasites is increasing around the world across many fish species, and we sought to assess whether marine mammals face a rising risk of intestinal infection due to this increase in anisakid burden of their potential prey items. We used data compiled from a recent meta-analysis of anisakid abundance in fish and invertebrates over the past 50 years. We then reviewed the diets of 33 species of IUCN- or ESA-listed marine mammal species to identify their key prey species. We extracted data on anisakid burden for each of the key prey species and tested whether anisakid abundance in these key prey species had increased over time. Our preliminary findings suggest that anisakid burden in key marine mammal prey species has increased over the past fifty years and could play a role in slowing the recovery of endangered and threatened marine mammals.

The importance of marine mammals at Isla Foca, Peru: Small scale monitoring and its large-scale conservation impact.

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Peru has become an epicenter for some of the world's most expansive extractive activities such as fisheries, mining and oil exploitation. With a 30% poverty rate in the country, these activities offer a source of employment and the opportunity to fight poverty. The region of Piura, in northern Peru, has 70% of Peru's extractive activities, and at the same time possesses the largest sources of anthropogenic disruptors. Here we analyze the importance of marine mammals at Isla Foca (S5°12'06.27" W81°12'31.47" – S5°12'51.18" W81°12'16.22"), to be identified as a geo-strategic center for monitoring human impact, critical for the conservation of the marine ecosystem in the north of Peru. By an observational, descriptive, exploratory and longitudinal methodology, we used geo-spatial analysis from the Landsat-5 imagery with high resolution monitoring the distribution and expansion of extractive activities, compared with cetacean sightings and pinniped population at Isla Foca since 2010. Our findings reveal a significant increase of threats surrounding Isla Foca and La Islilla, a small-scale fishing village, also exposed to these threats. Mining and oil distribution plants originally absent are now present. Increased density of fishing boats (from 15 to 157) overlapped the decline of cetacean sightings (N=177 for 6 species) from 36 to 3 per year while sea-lion population

declined from 982 to 114 individuals in the same time period. In the outcome of this analysis, we were able to visually and interpret the geo-oceanographic extent and increase in fisheries, oil platforms and mining. The rapidly expanding extractive activities and their potential hazards can cause irreversible damage, while there is a growing concern for its implications on the marine biogeochemical cycle that can affect marine mammals, humans and the ocean's health. Until today, the proposal of Isla Foca as part of the Mar Pacifico Tropical (Tropical Pacific Sea) Protected Area remains archived.

Fish in - fish out! I pull - you bite!

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Food-sharing is a prime example of altruism, a behaviour that reduces the actor's fitness while increases the recipient's. Despite of Darwin's theory of the survival of the fittest, altruistic behaviours are present in both human and non-human populations, including cetacean. According to our knowledge, this study is the first systematic testing, designed to investigate altruistic food-sharing in dolphins, focusing on role separation and mechanism.

The study involved five, male Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), including a father-son pair and three dolphins from the same mother. A novel cognitive enrichment device was designed for potential altruistic food-sharing, made of a PVC tube with two caps and handles. One end of the device was fixed to the poolside the other was free for the dolphins to interact with it. The device contained an internal plastic plate that could hold five capelins and was connected to the free handle with an elastic band. Thus, the fish could only be accessed if one dolphin pulled and kept the device open revealing the internal plate. In addition to the trial outcomes, the dolphins' partner choice in play and swim activities was also recorded.

A total of 188 (31%) fish were removed in altruistic manner with the participation of all five dolphins. Two dolphins preferred the role of 'consumer', three preferred to be 'actors'. Reciprocation was recorded only on a single occasion, while food-sharing between kin (98 occasions) and non-kin (90 occasions) was near equal. Positive correlation was found between partner choice in food-sharing and other social activities. In conclusion, group augmentation is a more likely explanation for food-sharing than reciprocity or kin-selection.

Our study provides an example of how ex-situ experiments could support conservation efforts by modelling and investigating behaviours that are observed in the wild but lack of full understanding.

Migration and foraging areas of baleen whales revealed by radiocarbon isotopic signatures of baleen plates.

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We investigated the use of radiocarbon isotope, carbon-14, in the baleen plates for reconstructing the migration history and foraging area of baleen whales in the western North Pacific Ocean. This new approach relies on the prominent latitudinal gradient of dissolved inorganic carbon $\Delta^{14}C$ values in surface seawater, which is characterized by low values (ca. -50 ‰) in the subarctic area (influenced by Oyashio Current) and high values (ca. 30 – 40 ‰) in the subtropical area (influenced by Kuroshio). Because $\Delta^{14}C$ -DIC signatures are transferred to higher trophic level organisms via food chain, the position-dependent change in $\Delta^{14}C$ of a baleen plate, from its root to tip, reflects the shift in the baleen whale's foraging area, serving as a useful recorder of its migration history. We examined five individuals of baleen whales stranded on the coast of Japan, including a calf of blue whale, a juvenile and an adult humpback whales and two minke whales. The tissues were sampled at a 1 cm interval from root to tip. The $\Delta^{14}C$-baleen values of the blue whale and the juvenile humpback whale were low regardless of position, suggesting that these individuals foraged only in the subarctic area. In contrast, the $\Delta^{14}C$-baleen values of the adult humpback whale displayed an unimodal pattern, with low $\Delta^{14}C$ values at the root and tip and high $\Delta^{14}C$ values in the middle. This indicates that the adult humpback whale migrated over a large scale, covering the

subarctic and subtropical areas during the period of its baleen formation. The $\Delta^{14}C$ -baleen values of the minke whale stranded on the coast of Japan Sea and the coast of Pacific were high and low, respectively, indicating the presence of intra-species variability in the foraging area among minke whales around Japan.

The growth and sex maturation parameters of harbor porpoise around Hokkaido, Japan.

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Harbour porpoises are susceptible to human activities because their habitats are mainly in the coastal areas. The biological parameters of harbour porpoises are extremely poor in Japan, even though it is essential to understand effect of human activities. Especially sexual maturation and growth are the factors that determine population dynamics. The activities of Stranding Network Hokkaido (SNH) enable to obtain samples of Harbour proposes on Hokkaido coast. In this study, we report sexual maturation and growth parameters of harbour porpoise in Japan. Date, location and length of 140 stranded porpoises were provided from SNH. Moreover, teeth of 58 porpoises were provided and age determination was conducted by using Growth Layer Groups (GLGs) to assess growth parameter. As a result, while the growth rate of males after 4 years old was less than 1cm per year, females grew up after 4 years old. Application of the Gompertz growth model to length at age data indicated an L_∞ of 177.1 cm in females and 135.8 cm in males, and it reflected sextual dimorphism. In sex maturation parameter, sexual maturation was determined based on Kasuya (1978) using 38 males and 19 females. The number of mature animals was only 1 male and 2 females, and it reported harbour porpoise in Japan appear sex maturation at least from 8 years old male and 3 years old female. Even though previous research in Atlantic Ocean or east Pacific Ocean reported considerable number of harbour porpoises under 1 year or pregnant individuals were stranded, it recorded 3 cases in the past 10 years in Japan as far as we know. In this way, it suggested that coast areas of Hokkaido were not used as a breeding area.

Assessment of Pacific white-sided dolphin migration patterns by burst pulse monitoring off the coast of the Syakotan Peninsula, Hokkaido, Japan.

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Pacific white-sided dolphins (PWS) migrate within both the Sea of Japan and the western North Pacific along the Japanese archipelago. Shakotan Peninsula, Hokkaido, Japan is known as an important route of PWS migrating along Sea of Japan. Little is known, however, about their migration patterns or their schooling patterns along the peninsula. Here we investigated seasonal and diurnal patterns of PWS occurrence along the peninsula by continuously recording their underwater vocalization. Two autonomous recorders were moored from April through June 2018 to capture their burst pulse (BP) sounds 24-hours. The largest number of BPs was recorded in early May and in the morning, indicating the seasonal and diurnal peak of their activity. In addition, BPs were recorded over several hours continuously, suggesting that dolphins did not merely pass through the area but stay there for feeding and/or resting. Additionally, the PWS produced stereotypic combinations of BPs (90 types in total), which should be used as group-specific signals. Of these, 14 types were repeatedly recorded over multiple days, and further 6 types were recorded even over multiple years. Furthermore, some types of BPS were recorded in pairs on multiple days. These results suggest that the same groups might regularly migrate to the Peninsula with other familiar groups. The present study reveals the migration pattern of PWS in the waters near the Peninsula and also the degree of intimacy in this PWS group affecting its fission-fusion dynamics.

Marine mammal acoustic presence in relation to sea ice concentration off Tasiilaq, East Greenland.

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The summer sea ice off the coast of southeast Greenland is increasingly retreating leading to longer and mainly sea ice free summer periods. This grants seasonally migrating cetacean species access to more coastal areas and allows them to stay longer in the feeding area, while habitat for ice-dependent species is decreasing. Only a few marine mammals (MM) surveys have been conducted in east Greenland and especially long time data on MM presence and seasonality is lacking. Hence, this study aims to assess the presence and the spatial and temporal distribution patterns of MMs in relation to the sea ice concentration in the waters off Tasiilaq, East Greenland, to establish a baseline of knowledge in distribution and timing of ice-dependent and migrating species off East Greenland. The Greenland Climate Research Centre collected passive acoustic monitoring data from August 2014 until September 2018. Autonomous acoustic recorders (AURAL-M2) were deployed at two positions: Kulusuk, 65.6°N; 37.4°W and Sermilik, 65.5°N, 38°W. These are currently being analysed visually and aurally for the daily presence of MMs. Preliminary analyses involved screening of every 7th recording in one year of data (September 2016 to September 2017). Fin whales were predominant and acoustically present from August to end of January. Humpback whales and bowhead whales were detected from June until end of January. However, the call differentiation between these two species is difficult and further effort will be required to differentiate between these species acoustic appearance in more detail. Sperm whale acoustic presence was detected from July until end of November. Bearded seal trills could be detected from late February until the end of June. This suggests that the area off Tasiilaq might be an important feeding ground for mysticetes and sperm whales, while bearded seals use the area during breeding season.

Acoustic activity patterns of the Antillean manatee (Trichechus manatus manatus) in Belize.

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Conservation of the endangered Antillean manatee (*Trichechus manatus manatus*) requires applying new technologies to monitor and protect them, especially in turbid habitats. In this study, we deployed passive acoustic monitoring (PAM) systems to detect wild manatees and document their diurnal and nocturnal acoustic activity patterns in the shallow, coastal habitats around St. George's Caye, Belize. A SoundTrap HF300 was bottom-mounted and deployed in a few locations to continuously record natural and anthropogenic sounds. Spectrograms were generated and analyzed using Raven acoustical analysis software (version 1.5) to quantify and measure the sounds (e.g., vocalizations, mastication) produced by manatees over time. Although there was some variability in activity patterns across the deployment locations and days, vocal activity tended to increase in the late night and early morning hours. A majority of the sounds produced by the manatees were multi-harmonic, tonal sounds described as squeaks that were suggestive of social interactions. Our results suggest that the resting holes and other shallow habitats in Belize are important areas for social and feeding activities, especially at night. These findings also demonstrate the strength of acoustic monitoring for detecting fine-scale trends in manatee activity, which can inform the management of this species in Belize.

Status of marine mammals in Papua New Guinea waters.

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There has been very little study of marine mammals in Papua New Guinea (PNG) waters, with most confirmed records from opportunistic sightings or limited dedicated surveys. As of 2007, 16 marine mammals were confirmed to inhabit PNG waters. At present the larger cetaceans are protected under national Whale Act & CITIES Appendix 1 and 2 at international level, there is no formal protection for small cetaceans at national level, only Dugongs and turtles are protected under the Fauna Protection and Control Act.

The lack of dedicated marine mammal study and appropriate legislation has resulted in limited knowledge of, and subsequent protection for, small cetaceans in PNG waters.

The project aims were to a.) provide a comprehensive review of marine mammal status in

PNG waters, b.) critically evaluate factors that may influence the success of coastal boat based surveys in PNG.

The comprehensive review resulted in 18 marine mammal species being confirmed from PNG waters, including two vulnerable coastal dolphins; the Australian snubfin dolphin (*Orcaella heinsohni*) and Australian humpback dolphin (*Sousa sahulensis*). These two species are not currently found elsewhere in the Pacific Islands. Constraining factors identified to do further marine mammals studies in PNG waters includes; limited local expertise, lack of government awareness, funding, and high logistic costs.

The results of this study have provided the PNG Government with a comprehensive summary of marine mammal diversity and important habitats in PNG waters. The data obtained from this study has been entered into a custom-made database to facilitate PNG's marine mammal's records and will be available for marine protected area planning. The database will soon be launched and it is hoped the study can now contribute information towards development of appropriate legislation to protect small cetaceans.

Evolutionary shifts in body size and signal frequency suggest independent evolutionary histories

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That body size and call frequency have an inverse relationship is one of the fundamental assumptions, or biological rules, in animal acoustics. However, recent studies have suggested that such constraints may be reduced in aquatic mammals like cetaceans. A possible explanation is that a rapid evolution of large body sizes in the aquatic habitat changed the relationship between these traits, resulting in a 'decoupling' that rendered signal frequency able to respond more strongly to natural selection. Because aquatic mammals rely on sound for their survival and reproduction, a signal frequency that is "free to evolve" could contribute to speciation in these lineages. To test this hypothesis, we examine evidence for rate shifts in body size and acoustic signal frequency, and speciation across three mammalian lineages within which aquatic life styles have evolved independently: Artiodactyla, Carnivora, and Afrotheria. We find that the evolutionary shifts in body size and signal frequency do not co-occur phylogenetically suggesting independent evolutionary histories. In contrast, we find that in the fully aquatic mammals signal frequency and speciation rates positively correlate, whereas in terrestrial or the semi-aquatic pinnipeds they do not. Our results show that through evolutionary time, the relationship between body size and frequency has been broken down in lineages with fully aquatic species, and that rapid evolution of signal frequency may contribute to diversification of these animals.

Bottlenose dolphin, Tursiops truncatus, seasonal distribution and behavioral response to a freshwater flood in Pensacola Bay, Florida.

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Pensacola, Florida experienced a flood on April 29, 2014, resulting in an unprecedented >2-meter freshwater surface layer (<5 ppt) throughout Pensacola Bay that gradually receded inshore over two months. Bottlenose dolphins (*Tursiops truncatus*) can suffer adverse health effects from prolonged freshwater exposure, but few studies have examined whether dolphins change their distribution in response to abrupt salinity changes. The study objective was to determine whether dolphins changed their distribution after the flood. We used data from a photo-identification, mark-recapture study to test the hypothesis that dolphins would either leave the area or move south towards more saline waters around the mouth of the bay. Four seasons were sampled twice across nine mark-recapture sessions from 2013 through 2016, plus an extra session in early spring prior to the flood, resulting in 78 surveys and 288 groups. Getis-Ord Gi* hot spot and kernel density estimate results showed that dolphins exhibit seasonal distribution patterns similar to other populations in Florida, in which dolphins use inshore areas during summer and move to the mouth of the bay during winter. Dolphins moved closer to the mouth of the bay where salinity was highest after the flood in spring 2014, but this distribution was not substantially different from that of spring 2015. Dolphins continued to exhibit their regular seasonal distribution patterns by moving further inshore during the summer after the flood despite low salinities (average ~8 ppt). Preliminary results suggest there was no significant relationship between distribution and salinity after the flood, but we are expanding our analyses to further explore these relationships. If dolphins are not moving

away from low salinity environments, then they may be at increased risk from abrupt changes in their habitat which can have implications for prey availability, population health, management, and conservation.

Mitogenomic phylogeny and comparative genomics support a third species in the genus Berardius.

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Beaked whale species are offshore, deep-diving, and cryptic, and some species have never been observed alive in the wild. Their phylogeny remains unresolved and a new species was proposed as recently as 2016. A dark-colored morph ("black form") of Baird's beaked whale (*Berardius bairdii*) in the North Pacific was suggested to represent a third unnamed *Berardius* species based on fixed differences within the mitochondrial control region. With the proposition of a new beaked whale species, the phylogeny of the genus *Berardius* and its evolutionary position with other beaked whale genera warrants revision. We sequenced complete mitochondrial genomes and whole-genome sequences for the three putative *Berardius* species. Divergence time estimates and phylogenetic relationships between the three species as well as between all five genera of beaked whale lineages were based on mitogenomes, modeled using a fossil-calibrated Bayesian phylogenetic approach. *B. arnuxii* and *B. bairdii* gray-form mitogenomes were most similar (98.1%), while the *B. bairdii* black form was less similar to *B. bairdii* gray-form and *B. arnuxii* (95.4% and 95.5%, respectively). The mitochondrial genomic analysis supported *B. bairdii* as a paraphyletic group, differing from its initial delimitation as monophyletic. For the draft genomes, the scaffold N50s were between 14,560 and 15,499 base pairs, and genome coverages were 31x (*B. arnuxii*), 17x (*B. bairdii* black-form) and 1x (*B. bairdii* gray-form). Effective population size trends in deep time were assessed by pairwise sequentially Markovian coalescent (PSMC). The complete mitogenomes and whole-genome sequences produced in this study provide a valuable resource for further beaked whale comparative genomics.

Cortisol binding globulin response to repeated ACTH administrations in juvenile northern elephant seals (Mirounga angustrirostris)

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Total cortisol concentration is frequently used in stress assessments. However, most circulating cortisol is bound with its carrier protein, cortisol binding globulin (CBG), and only a fraction of total cortisol is unbound ("free" in circulation) and able to interact with target receptors. Understanding stress-related fluctuations in CBG will better enable interpretations of increased cortisol concentrations. We previously administered ACTH to juvenile northern elephant seals (n = 7) once daily for four consecutive days and assessed total circulating cortisol levels in a time series of samples collected after ACTH administration on days 1 and 4 (a single sample was taken prior to ACTH administration on days 2 and 3). Here, we measured corresponding concentrations of CBG and calculated CBG influence on circulating cortisol. Statistically significant variation in CBG concentration followed the first ACTH administration on day 1 ($p < 0.05$), but there was no difference between baseline and subsequent samples (Dunnett's test; $p > 0.05$). No differences were found in CBG concentrations on day 4 relative to the day 4 pre-ACTH sample. Bound cortisol concentrations increased on day 1 but did not fluctuate on day 4, likely due to an ACTH-induced increase in total cortisol concentration and subsequent saturation of CBG. Free cortisol concentrations significantly changed on day 1 and day 4 ($p < 0.05$); CBG levels in most samples from each day were higher than pre-ACTH levels from that day. These results suggest that CBG concentration may not significantly alter interpretations of the total cortisol response to ACTH administration in juvenile northern elephant seals.

Investigating the presence of invertebrate prey and parasitic load via hard parts analysis and next-generation sequencing in a northwest Atlantic population of the grey seal (Halichoerus grypus)

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Pinnipeds such as the grey seal (*Halichoerus grypus*) are ecologically important in marine ecosystems as they shape community structures via top down effects. Following near extirpation in the mid-1900s, grey seal populations continue to rise today in the northwest Atlantic. Many controversies surround grey seal diet in terms of competition with local fish populations, but few studies have attempted to analyze the impact of grey seals on invertebrate communities in United States waters. Invertebrate prey remains may be quickly digested, leading to potential bias in diet studies that rely on the passage of in-tact hard prey remains. Hard parts analysis of seal scat samples (N=113) was combined with next-generation sequencing of prey DNA in seal scat from two breeding sites in Massachusetts, USA. A metagenomics approach also allowed for the assessment of grey seal parasitic infection rates and potential correlations between parasite species and grey seal predation on invertebrate and vertebrate prey. Invertebrate prey was detected in 6 samples via hard parts (6.1%) but in 35 samples via next generation sequencing (36%). Similarly, 5 species from Decapoda and Bivalvia were detected via hard parts, whereas 10 orders were identified through sequencing, including Decapoda, Copelata, and Mytilida. At least one type of parasite was present in 86% of seal scat samples, with nematode infections (83%) more prevalent than either trematode (33%) or tapeworm (20%) infections. Neither seal sex, parasite load, nor parasite type affected the number of prey species per sample, prey biomass per sample, or the diversity of prey species within each sample. The results indicate previous studies on grey seal diet may be underestimating the diversity and importance of invertebrate prey in the diet, but further research is needed to address how parasitic load could be affecting grey seal diet.

Long-term variability in spinner dolphin acoustic activity measured at two resting bays off Oahu, Hawaii

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Spinner dolphins (*Stenella longirostris*) frequent the Waianae coast of western Oahu as part of their daily behavioral routine of foraging at night on offshore, mesopelagic prey and resting during the day in shallower, inshore waters. Dolphin resting habitats are in close proximity to human activities—particularly swim-with dolphin tours—which raises concern for the potential disturbance of their crucial resting behavior. Makua Beach and Kahe Point are two well-studied spinner dolphin resting habitats on the Waianae coast. Recent deployments of bottom-moored acoustic recorders have sampled the soundscape at both locations intermittently from 2016 to 2019. Acoustic data were also collected from both sites in past studies between 2008 and 2009. These historical data provide the opportunity to quantify the difference between soundscapes and dolphin acoustic activity over time at these locations. Data subsets were taken from March-May of 2008, 2017, and 2019 for Makua Beach, and from March-May of 2009 and 2019 for Kahe Point. Daytime recordings from these deployments were manually scanned for dolphin signals, and dolphin acoustic activity was quantified using an index based on the amount and type of calls in each recording. Acoustic activity was then used as a proxy to examine variability in the spinner dolphins' use of the two resting habitats over an approximately 10-year period. Additionally, the mean sound pressure level of each deployment was calculated in 1-octave frequency bands to characterize the ambient noise levels. Determining the variation in dolphin acoustic activity and ambient noise between years and across sites can inform management of spinner dolphins' potential to adapt to changing environments.

Seasonal and spatial occurrence of Brucella ceti in stranded bottlenose dolphins (Tursiops truncatus) from South Carolina, USA waters

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Brucellosis is a disease caused by the gram-negative facultative intracellular bacterium *Brucella* spp. This zoonotic bacterium in terrestrial species is a global public health risk, and there is also concern over the zoonotic potential of marine forms, such as *Brucella ceti*, which affects cetaceans. Due to the detection of *Brucella ceti* in

samples from bottlenose dolphins (*Tursiops truncatus*) during the 2010-2014 Gulf of Mexico Unusual Mortality Event, a long-term study of the prevalence of *Brucella* in stranded bottlenose dolphins from South Carolina was conducted. From 2012 through 2017, 282 stranded bottlenose dolphins were tested for *Brucella ceti* via real-time PCR, using the QIAamp DNA Mini Kit for amplification and primers directed at the IS711 gene. Nearly 32% of the dolphins tested positive for at least one sample (brain, lung, blowhole swab). Very little information exists in the literature on seasonal occurrence of *Brucella* in marine species, though in terrestrial species higher prevalence is often reported in spring. Similar results were found in this study with the peak occurrence being between March and June, a known period of calving in South Carolina. When observed spatially, Hot Spot Analysis using ArcGIS Desktop, the 12-Digit Watershed Boundary Dataset in Hydrologic Unit Code 8 (HUC) geodatabase for South Carolina, and the Getis-Ord Gi* statistic, features around Charleston, South Carolina had statistically high clusters spatially of *Brucella ceti* in dolphins. These features are in urban areas influenced by both industry and agriculture. Results from this study provide important insights into the seasonality and spatial influences of the marine bacterium *Brucella ceti*.

What's in a name? Motivational information within signature whistles of Indo-Pacific bottlenose dolphins (Tursiops aduncus).

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Bottlenose dolphins produce individually distinctive whistles called "signature whistles". These are thought to contain individual identification information within the frequency modulation pattern and function as contact calls between conspecifics. Here, we investigate if signature whistles also contain other information regarding the vocalizing individual, for example their motivational state. "Motivation" in non-human animals refers to the drive to carry out a behavior, and previous research on terrestrial species' has identified vocal parameters which carry this information. Signature whistles from a group of 11 provisioned wild Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) were recorded using a static hydrophone array. Each whistle was localized and assigned to the vocalizing individual. Simultaneous video footage was used to record the behavior of the whistling individual at the time of whistling. From the video footage, three behavioral states were classified using a *K*-means cluster analysis with a principal components analysis; low arousal, high arousal/aggressive and high arousal/sexual. We then determined whether differences in signature whistle parameters (i.e. start/end/min/max frequency, bandwidth, duration, inflection points, frequency trend) were linked with different behavioral states. A total of 18 days of recording produced 772 useable whistles to analyze (i.e. high signal to noise ratio, localizable, in camera view). Results from the preliminary analysis of one adult male's signature whistle (n = 82) indicate that whistle duration increased, and whistle end frequency decreased, as the individual's arousal level increased. Based on terrestrial studies, whistle duration was expected to increase with arousal, however, end frequency was not expected to decrease. These preliminary results suggest that signature whistles do contain other information besides individual identity. However, further analyses on the other group members and more in-depth behavioural analyses are needed to determine whether this is linked to motivational state.

Phylogenomic resolution of the cetacean tree of life using target sequence capture.

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The evolution of cetaceans, from their early transition to an aquatic lifestyle to their subsequent diversification, has been the subject of numerous studies. However, while the higher- level relationships among cetacean families have been largely settled, several aspects of the systematics within these groups remain unresolved. Problematic clades include the oceanic dolphins (37 spp.), which have experienced a recent rapid radiation, and the beaked whales (22 spp.), which have not been investigated in detail using nuclear loci. The combined application of high-throughput sequencing with techniques that target specific

genomic sequences provide a powerful means of rapidly generating large volumes of orthologous sequence data for use in phylogenomic studies. To elucidate the phylogenetic relationships within Cetacea, we combined sequence capture with Illumina sequencing to generate data for ~3200 protein-coding genes for 68 cetacean species and their close relatives including the pygmy hippopotamus. By combining data from >38,000 exons with existing sequences from 11 cetaceans and seven outgroup taxa, we produced the first comprehensive comparative genomic dataset for cetaceans, spanning 6,527,596 aligned base pairs and 89 taxa. Phylogenetic trees reconstructed with maximum likelihood and Bayesian inference of concatenated loci, as well as with coalescence analyses of individual gene trees, produced mostly concordant and well-supported trees. Our results completely resolve the relationships among beaked whales as well as the contentious relationships among ocean dolphins, especially the problematic subfamily Delphininae. Our analyses continue to support the paraphyly of genera such as *Balaenoptera*, *Sagmatias*, *Cephalorhynchus*, and *Stenella*. We performed Bayesian estimation of species divergence times using MCMCtree, integrating recently described fossils. Divergence dating analyses indicates that the diversification of Crown Cetacea began as early as the beginning of the Late Eocene and the divergence of Crown Delphinidae as early as the Middle Miocene.

Turning the tide: Addressing increasing adverse human-dolphin interactions through complementary research and outreach approaches.

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Bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida experienced a dramatic increase in adverse human interactions (HI) following a severe red tide (*Karenia brevis*) harmful algal bloom that decimated prey fish populations in 2005-2006. Injuries from recreational fishing gear and unnatural foraging behaviors focused on anglers' bait and catch spread throughout the long-term resident dolphin community and remained elevated for several years post-bloom, motivating sustained research and outreach efforts to better understand and mitigate HI. In addition to fisheries interactions, dolphins in Sarasota Bay face high levels of recreational boat traffic with frequent disturbance from close approaches and boat-based viewing activities. Here we summarize field and outreach approaches that have been most effective to assess and address the large suite of HI concerns in our region, including new techniques we are testing to monitor interactions and engage stakeholders, which may be applicable at other sites dealing with impacts from widespread recreational fishing and boating activities. Traditional photographic-identification surveys document anthropogenic injuries and provide baseline data to assess long-term trends in prevalence and frequency of unnatural foraging behaviors by resident dolphins. Stranding network reports facilitate opportunities to rescue injured animals and confirm fates of those succumbing to anthropogenic injuries. Dedicated sampling at identified HI hotspots, including focal animal behavioral observations and remote monitoring via deployment of passive acoustic and multi-view video systems enhances these efforts, providing comprehensive interaction data helpful to more efficiently target educational outreach efforts. Community engagement focuses on stakeholder groups whose activities overlap with and impact resident dolphins, encouraging best practices in three areas: 1) safe boating and fishing near dolphins, 2) preventing injuries through marine debris reduction, and 3) effectively reporting injuries and interactions to expedite intervention and facilitate monitoring.

Celebrating our marine mammal community: Researchers, educators and conservationists.

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The diversity of members of the marine mammal community is rich, and wide-ranging. The typical Biennial conference hosts an average of 1,700 attendees, with over half of them giving presentations on a broad-range of topics, from anatomy and taxonomy, to policy and education. What is the common thread amongst this diverse community? Is it just the subject matter? And as a community, who are we? Is the overarching interest of the

community solely information gathering? Is there a fundamental concern for conservation and awareness? Looking at the interests and motivations of individual members of the community will help to identify the overall motivation and aspirations of the entire community.

A survey of the marine mammal community investigates these questions to develop a baseline understanding of the community's interests and strengths. Science, education and advocacy are all important components of marine mammal research and conservation. How do individual members identify within these three categories? How much overlap is there? Do you feel confident in all three areas, or would you prefer to partner with others that can help provide data for your advocacy campaigns, or educational curriculum? Collaborations can connect specialists with outcomes that can empower each other to improve methods, materials and impact.

Reduction in Australian fur seal pup numbers limited to the larger breeding sites.

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Ecosystem change may be evident in trends of annual pup production by fur seals, which are top-predators with large biomasses. South-eastern Australia is a global hot-spot for ocean warming and Australian fur seals (*Arctocephalus pusillus doriferus*) reside year-round in these waters. Changes to prey species availability due to local ocean warming will likely result in changes to Australian fur seal distribution and pup production. Our aim has been to establish a monitoring system to document trends in pup production, and clarify factors causing change. After near extirpation in the 1800s, and a stifled population recovery caused by on-going lethal interactions with emerging fisheries, the population increased during the 1990s. To document population status, four species-wide censuses were performed in the Austral summers of 2002, 2007, 2013 and 2017. These, plus opportunistic estimates at individual colonies, were used to examine population trends since 1989. In 2007, pup numbers peaked at 22,900. Then, for the first time since recovery began, numbers reduced between 2007 and 2013, at an apparent rate of 4.2% per annum (p.a.). Breeding sites with >2000 pups experienced a 20–50% reduction, but some smaller sites showed increases. The apparent decline might have been due to annual variability; however, further monitoring has confirmed the decline. In 2017, pup numbers had reduced again, at a rate of decline of 1.4% p.a., to 15,600 pups. Factors considered to be contributing to this reduction include fisheries interactions and environmental pollutants affecting survival and reproductive rates. Teasing out changes due to ocean warming and those due to other factors will require on-going monitoring. Current research is focussed on using drones to increase survey frequency and minimise the disturbance caused by on-ground based pup counting methods, partnering with the fishing industry to reduce marine debris entanglement and bycatch and documenting changes in prey species abundances, and identifying health factors affecting vital rates.

Sights, sounds and touch: Wearable brain imaging using functional near-infrared spectroscopy.

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We tested the efficacy of functional near-infrared spectroscopy (fNIRS), a wearable non-invasive biomedical imaging technique which measures oxy- and deoxyhemoglobin concentration changes, to detect cortical activation in grey seals (*Halichoerus grypus*) (n=5) and identify regions of the cortex associated with different senses (vision, hearing and touch). When neurons are activated, their increased metabolism reduces O_2, triggering a hemodynamic response that increases the delivery of oxygenated blood. Active regions of the brain, therefore, have higher oxygenated haemoglobin concentrations [HbO] than inactive regions. By comparing the absorption of near-infrared light at two frequencies, one of which is absorbed more by HbO and the other by deoxyhemoglobin, fNIRS

can non-invasively measure changes in blood volume and oxygenation in brain tissue. We used a standard human fNIRS experimental framework to test this method on a marine mammal species. An array of fNIRS sensors was used with 5 grey seals in the presence and absence of sensory stimuli – light for vision, sound for hearing and vibrissal stimulation for touch. The magnitude of the activation signal ranged from 0.4-0.6 $\mu.mol.L^{-1}$, with statistically significant differences ($p<0.05$) between [HbO] during the presence and absence of all stimuli. Specific areas of cerebral activation were associated with each primary sensory pathway. These were similar to those of other carnivores (dogs and cats), as was the associated frontal cortical activation. There was marked contralaterality in regional activation associated with stimulation of the eyes and whiskers. Auditory stimulation displayed differences in activation between the right and left hemispheres of the frontal cortex, potentially indicating lateralisation in the processing of sound in seals. Thus, fNIRS can successfully detect cortical activation in grey seals. fNIRS is non-invasive and wearable, with fewer movement artefacts than EEG, suggesting that it may offer a new tool to quantitatively investigate sensory perception in free-ranging marine mammals.

Using side-scan sonar with GIS applications for marine mammal research

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Understanding how animals interact with their environments is crucial to aiding conservation and habitat preservation. Since the benthic zones of marine habitats are not always easily observable from the surface, it is necessary to employ alternate techniques. Side-scan sonar is one such technique that is both time and cost effective. Side-scan sonar allows large areas to be surveyed in a relatively short amount of time, providing information about benthic substrates as well as bathymetric data. These data can then be paired with GIS (Geographic Information Systems) applications to assess habitat use. In this study, the reliability of low cost side-scan sonar to accurately identify soft substrates such as grass and mud was tested. A total area of 11.5 km^2 was surveyed with the sonar in a large, brackish mangrove lagoon system. Individual points were ground-truthed for comparison with the sonar recordings to provide a measure of accuracy. Five substrate types were identified: Dense seagrass, sparse seagrass, mangrove soil, mangrove soil with rock, and silt. A zoned benthic substrate map was created from the sonar recordings. Dense seagrass was most accurately identified. Sparse seagrass had the lowest accuracy. A bathymetric map was also created from the sonar recordings with depths ranging from 0 to 10.3 m. Georeferenced manatee sightings were overlaid on these maps using QGIS (Quantum Geographic Information System) to preliminarily assess habitat use. Most manatee sightings occurred in areas 2–6 m deep and characterized as mangrove soil.

Gross and histopathologic diagnoses from North Atlantic right whale (Eubalaena glacialis) mortalities between 2003 and 2018.

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Seventy mortalities of North Atlantic right whales, *Eubalaena glacialis* (NARW) were documented between 2003 and 2018 from Florida, U.S.A. to the Gulf of St. Lawrence, Canada. This included 29 adults, 14 juveniles, 10 calves, and 17 unknown age class. Females represented 65.5% (19/29) of known-sex adults. Fourteen cases had photos only; 56 carcasses received external examinations, 44 of which were also necropsied. Cause of death was determined in 43 cases, 38 (88.4%) of which were due to anthropogenic trauma: 22 (57.9%) from entanglement and 16 (42.1%) from vessel

strike. Gross and histopathologic lesions associated with entanglement were often severe and included: deep lacerations caused by constricting line wraps around the flippers, flukes, and head/mouth; baleen plate mutilation; chronic extensive bone lesions from impinging line, and traumatic scoliosis resulting in compromised mobility in a calf. Chronically entangled whales were often in poor body condition and had increased cyamid burden reflecting compromised health. Vessel strike, blunt force injuries included skull and vertebral fractures, blubber and muscle contusions, and large blood clots. Propeller-induced wounds often caused extensive damage to blubber, muscle, viscera, and bone. Overall prevalence of NARW entanglement mortalities increased from 21% (1970-2002) to 51% during this study period. Thus, despite mitigation efforts, entanglements and vessel strikes continue to inflict profound physical trauma and suffering on individual NARWs. Their cumulative impacts at the population level are unsustainable. Urgent and aggressive intervention is needed to end anthropogenic mortality in this critically endangered species.

An investigation into the fine scale habitat use of fin whales (Balaenoptera physalus) in the Celtic sea.

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Marine mammal sightings and effort data have been collected annually in the Celtic Sea by the Irish whale and dolphin group during Irish Marine Institute research cruises since 2004, and by Marinelife during CEFAS research cruises since 2013. Fin whales have been increasingly seen in certain areas but there have been no specific studies to investigate when and why Fin whales are present in the Celtic sea. Recent studies suggest fin whale distributions are changing globally, and that they are utilising productive mid latitiude feeding grounds along migration routes more than before. This project merged different datasets for a broader spatial and temporal resolution, to investigate the key drivers of distribution for the fin whales during the autumnal months when the surveys occur to test the hypothesis that they are feeding there. There were significant challenges to using the combined dataset and methods were first developed to correct inconsistencies in the data, including cutting and combining segment sizes to create evenly sized segments which met the assumptions required for distance sampling techniques. Then a two-stage count model was developed using Multiple Covariate Distance Sampling to calculate a detection probability and correct the fin whale densities. The corrected counts were used with General Additive Models to explore which environmental covariates were significant to the distribution of fin whales. Initial results show that fin whales prefer depths between -100 and -70 metres below chart datum; and either high or low tide heights between -0.5 to -1.5 m below, or 1 to 2m above chart datum, but seemingly avoiding slack tide. Further data is being added to the model to continue to investigate their distribution and in particular test the significance of the Celtic deep as a likely feeding area.

An assessment of UAS technology for studying Atlantic spotted dolphins.

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Studying dolphins in the wild is complicated by the limited effectiveness of vessel-based observation. In particular, visually observing dolphins in a manner which allows researchers to track individuals and their interactions with conspecifics and the environment is challenging. The presence of a research vessel may also cause behavioral disturbance. We address these issues by assessing the feasibility of a small unmanned aerial system (UAS) for behavioral observation, habitat classification, and both respiration and photogrammetric measurements. In 2018, we conducted 6 UAS flights to follow and record Atlantic spotted dolphins (*Stenella frontalis*) in the Northern Bahamas. Dolphins displayed no observable behavioral response to the UAS at altitudes as low as 5 meters. During video review we documented 19 different behaviors within 5 behavioral states: travel, rest, play/socialize, aggression and courtship. Referencing the vessel-based or underwater observation notes taken prior to each flight, 92% of fused (mature adult, n=14), 100% of mottled (young adult, n=2), 50% of speckled (juvenile, n=8) and 60% of two-toned (calf, n=5) individuals were identifiable in videos for which group size was small (<10 dolphins). All dolphins documented underwater prior to a UAS flight were identifiable in respective video. Benthic habitats sand (n=4), sand/grass (n=5), reef/rock (n=1), and deep water (n=1), were visually discernable in all flights. Respiration rates of traveling dolphins were quantifiable at altitudes of up to 60 meters and averaged at 1.8 breaths per minute. Additionally, preliminary photogrammetric

measurements of a stranded, rehabilitated, and released dolphin suggest that body measurements via UAS are feasible. These findings indicate that UAS have the potential to improve fieldwork methodologies, allowing more detailed observations and measurements of dolphins and their environment. We anticipate UAS technology becoming more prevalent in both our continuing research, and that of other marine mammal scientists.

Science education; The redundant phrase that is a call to action for all scientists to "Pay it Forward" by adopting young students and sharing their work. A win-win model for inspiring STEM careers.

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Student engagement in STEM fields is enhanced by direct contact with established scientists working on current projects. Given the opportunity to rub shoulders with scientists, students are more likely to explore and choose a career in the sciences. It is a simple fact that doing science is the ultimate education process as it integrates many facets of learning. Scientists are constantly educating themselves. They are life long learners by default. Nobody has to learn how to be a scientist, quite the contrary. People have to learn how not to be scientist. Almost every young person is curious and therefore naturally acts like a scientist by asking questions, performing experiments, collecting data and forming conclusions. Have you ever seen a four year old examine a caterpillar? Puberty is a critical time when young people begin to put their curiosity aside and instead start dealing with social, emotional and physical growth. Young people lose their curiosity easily if they are not encouraged, especially at school where much of their life centers. Young people stay curious if they are exposed to authentic science experiences. But these experiences are few and far between. Science teachers benefit greatly when scientists interact with their students. The formula for keeping students engaged in the sciences includes direct contact with scientists and their work. This is a clear call for scientists to share their work with young people. Scientists are natural teachers and through the articulation and translation of their work to young people scientists strengthen their own understandings and students are inspired to become scientists. Scientists can help maintain the curiosity in young people simply by engaging young people in their own work. Examples of scientists mentoring middle school students and inspiring students to go into STEM fields are provided from a teacher's perspective.

Characterising the small vessel fleet using passive acoustics: Implications for Southern Resident killer whale critical habitat management.

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Anthropogenic noise from vessels, ranging from large cargo ships to small pleasure boats is increasingly being recognized as both a persistent and pervasive pollutant. Furthermore, the spatial and temporal variability of vessel noise represents a significant challenge for implementing marine conservation, management and planning measures. While large vessel traffic (> 300 GT) can easily be tracked using mandatory Automated Identification System (AIS), no similar method exists for monitoring the movements of smaller vessels, which are not required to broadcast over AIS. This poses a challenge for understanding the contribution of small vessels to the marine soundscape, particularly in densely populated coastal regions. This study explores the use of passive acoustics to capture information related to non-AIS vessels in Boundary Pass, a recognised important foraging area for endangered Southern Resident Killer Whales (SRKW) within the Salish Sea. An acoustic vessel detector, a land-based camera and an AIS system were used in conjunction to gather information about the type and behaviour of non-AIS vessels using this important area.

This presentation will outline how information related to non-AIS vessel traffic can potentially be classified using acoustic data and used to predict small vessel presence and properties such as type and speed of boat within a localised area. This work aims to provide managers and decision-makers with insights about how we can capture quantitative and qualitative data related to the non-AIS vessel fleet, and highlight the importance of having this knowledge for making informed decisions. In the Salish Sea, non-AIS or small vessel traffic is currently largely unaccounted for in management assessments and noise models often due to insufficient data. Therefore the specific goal of this work is to help inform future management

and monitoring plans for vessels within SRKW Critical Habitat.

The characterization of the toxicologic effects of particulate hexavalent chromium in female and male fin whale cells.

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Chromium is a global marine pollutant and high chromium levels have been reported in North Atlantic whales including fin whales. This study focuses on hexavalent chromium [Cr(VI)] and uses zinc chromate as a representative particulate Cr(VI) compound because it is commonly used as an antifouling and anticorrosion agent on marine boats and equipment, making it a likely source of chromium exposure for whales. We characterized the toxicity of particulate Cr(VI) in skin fibroblasts from both sexes of fin whale (*Balaenoptera physalus*). Hexavalent chromium is a known carcinogen and reproductive and developmental toxicant. Although the mechanism underlying its toxicity is uncertain, it is clear DNA damage, manifested as strand breaks and chromosomal changes, plays a central role. Therefore, in this study we analyzed the cytotoxic and genotoxic effects of both acute (24h) and prolonged (120h) particulate Cr(VI) exposures. Particulate Cr(VI) induced a cytotoxic and genotoxic response in a concentration dependent manner in both sexes. Both acute and prolonged exposure induced similar amounts of cytotoxicity, but prolonged exposure induced less genotoxicity than acute exposure. Intracellular chromium was lower after prolonged exposure than acute exposure. These data suggest whale cells may have mechanisms to reduce Cr accumulation inside the cell that may trigger cell death pathways. Cells from both sexes responded similarly. Overall, compared to previously published data in human cells, both fin whale sexes showed a resistance to Cr(VI), as prolonged particulate Cr(VI) exposures in human cells increased the amount of toxicity. This suggests marine mammals may have developed cellular mechanisms to counterbalance chromium induced toxicity. In the future, assessing cellular mechanisms activated after the Cr(VI) exposure, such as, Cr transport, DNA repair and cell death pathways, could provide insights into why fin whale cells are resistant to genotoxic agents. This work was supported by NIEHS grant ES016893 (J.P.W.).

Collateral mortalities of marine mammals in small-scale fisheries: Too big to ignore.

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Small-scale fisheries (SSF) often are perceived as individually sustainable, but comprise 95% of global fishers and cumulatively represent marine ecosystem threats, which encompass collateral mortalities. Marine mammals are particularly vulnerable to SSF and have been the focus of conservation strategies. However, in many cases, such strategies have fallen short of objectives and effectiveness. This study aimed to elucidate the associated issues by compiling global mitigation measures among SSF and identifying: (i) successful measures and their influencing factors; (ii) information deficits; and (iii) a coherent approach to success. Among 113 peer-reviewed articles (1994–2019) there was exponential temporal output, and while gillnets were the most studied (72%), efforts have recently expanded to other gears. Approximately 68% of publications proposed mitigation measures, but only 42% assessed relative effectiveness. The latter studies recently decreased, implying less time is spent discussing improvements. Community engagement is essential for conservation, but was the least used approach (39%). Nonetheless, it has increased greatly, as the past decade represented 84% of these publications. This increase appears correlated with studies describing management approaches at the expense of typical bycatch assessments. European and North American fisheries were the most studied, whereas those in Africa were the least. Mitigation approaches were categorized as: (i) spatio-temporal fishing closures (30 studies); and modifications (ii) within existing gear configurations (3); (iii) beyond existing gear configurations (18); or (iv) to operational and/or post-capture handling (7). These categories were assessed in 'strength, weaknesses, opportunities, threats' (SWOT) analysis. While common strengths and weaknesses varied, opportunities and threats were similar. From success studies (68%), mitigation measures should optimally benefit multiple species ('strengths'), avoid regular maintenance ('weaknesses'), improve governmental aid and community engagement ('opportunity'), and consider non-compliance ('threats'). Options are available to protect mammals from SSF, but these require impetus for

adoption, which is best done via community engagement.

Risk of collision between Tursiops truncatus (Montagü, 1854) and merchant ships in the National Park "Sistema Arrecifal Veracruzano", México.

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The Veracruz Reef System National Park [UdMO1] (PNSAV by its acronyms in Spanish) is an area of economic, social, cultural and ecological importance which houses more than 3,000 species such as coral reefs, seagrasses and vertebrates including marine mammals. Currently, the local port is expanding their facilities, so was needed a monitoring program to assess the potential impacts in the local wildlife and the marine ecosystem. In order to analyze spatial and temporal density and the risk of collision between merchant ships and bottlenose dolphins, 63 boat-based navigations were developed from 2016 to 2017 troughout the study zone divided into four zones, recording geographical positions of both dolphins and ships and an index of collission was estimated. A total of 274 individuals of *T. truncatus* were registered mostly in front of the port of Veracruz, while 380 merchant ships had a greater density in zone three in front of the Jamapa river. In terms of temporal density, bottlenose dolphins and ship presented a higher density in the Cold Fronts season, being distributed closer to the coast. Likewise, the general Collision Index was 0.78, indicating that there is a high risk of collision. In the same way, a higher Collision Index was found in the northern season and in the area in front of the port of Veracruz. This study is one of the first to analyze the risk of collision between bottlenose dolphin and ships in the PNSAV, and constitutes a valuable input for both the port administration and environmental skateholders to conserve this species as a bio-indicator of marine ecosystem health.

Keywords: density, distribution, Collision Index, marine mammals, merchant ships.

[UdMO1]Please check if other papers how is it mentioned? English or Spanish?

Hormones and whales: Unveiling physiological mysteries of blue and gray whales in the North Pacific Ocean.

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Identification of biomarkers that reflect the physiological status is fundamental for assessing population health, as well as to provide more accurate estimates of life history parameters. Recovered from commercial whaling, both blue (*Balaenoptera musculus*) and gray (*Eschrictius robustus*) whale populations feed on lower trophic levels and migrate between the Eastern Tropical and the Eastern North Pacific Ocean. With increasing disturbances (e.g., changing environment and human activities), understanding the physiological stress response and coping mechanisms is of growing importance. Here we validated assays for steroid hormones in blubber samples from live and stranded blue (n=73) and gray (n=15) whales, and then evaluated existing relationships among hormone concentrations, health status, and reproduction.

Reproductive status was determined for females (pregnant vs. non-pregnant) using progesterone concentrations and for males (immature vs mature) using testosterone concentrations, coupled with sighting history data. Validation of stress-related corticosteroids indicated that detection and concentrations of corticosterone, cortisol and aldosterone varied among species and between sexes. In blue whales, cortisol was validated in both sexes, while corticosterone was detectable only in females, and aldosterone only in males. Preliminary results show higher corticosterone concentrations compared to cortisol, in stranded animals, but not in live whales. No difference in concentrations of either of these hormones was found between pregnant and non-pregnant females. In gray whales, assays of both sexes validated for all three corticosteroid. Corticosterone and cortisol concentrations showed no difference between

males and females, in this species. Blubber depth analysis showed cortisol to be more concentrated in the outer layers (closer to skin), while corticosterone concentrations did not change across the depth of the blubber sample. Hormonal biomarkers linked with resighting histories of large whales provides valuable insight into long lived animals whose populations are in need of supplemental life history information.

Examining shark bite scars on bottlenose dolphins (Tursiops truncatus) off Bimini, The Bahamas

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Bottlenose dolphins *(Tursiops truncatus*) off of the coast of Bimini, The Bahamas have scarring and/or injuries that can be attributed to non-fatal shark attacks. However, the rate of shark predation on small cetaceans in general is limited as it is often dependent on the identification of crescent-shaped injuries or scars as indicators of shark attacks. Photo-ID and behavioral research in Bimini is ongoing and can be used to assess the prevalence of shark-induced injuries on bottlenose dolphins to evaluate their predation risk. In this study, photographs of individual dolphins were analyzed to describe the presence, shape (e.g., crescent or linear), and location of scars. Initial analysis suggests at least 10 (7.7%) of the 130 dolphins in the current catalog have scars or injuries likely attributed to sharks, with another 22 dolphins (16.9%) with undetermined scars. Most of these scars were located on the dorsal side of the peduncle area, rather than the ventral side which would more likely result in fatality. Based on the regions these scars are located, we estimate the angle of attacks resulting in non-lethal bites and compare these injuries to reports of attacks on dolphins in other geographic locations as well as sympatric Atlantic spotted dolphins. This information contributes to longitudinal studies of the dolphins in this region and provides insight into the predator-prey relationship between shark species and dolphins off Bimini.

The truth in scat: Effects of season, location, and year on diet composition of grey seals (Halichoerus grypus) in New England.

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The expanding Northwest Atlantic population of grey seals, *Halichoerus grypus,* has generated a number of presumed conflicts with commercial fisheries in New England. This has led to an ethical debate with many now questioning the ecological roles of grey seals in the New England ecosystem. We used hard parts analysis of grey seal scat to determine if grey seals are contributing to the depletion of commercially important fish species, most notably Atlantic cod (*Gadus morhua*), to assess determinants of diet variation, and to ascertain their overall diet composition. Two hundred fifty seven scat samples were analyzed from two locations, Muskeget and Monomoy Islands, MA over multiple seasons from 2004-2018. Analysis included sieving samples to identify prey remains; otoliths found were identified and measured to calculate prey species and biomass, as the length of an otolith can be used to calculate the length and wet weight of a prey item. Three variables were examined in relation to biomass and prey richness (the number of prey species present in each sample): season (spring/summer), location, and period (old = 2004-2009, recent=2010-2018). It was determined that season (p=0.018), location (p=1.44x10^{-6}), and period (p=0.001) all had significant effects on total prey biomass, but only season (p=0.004) and period (p=0.009) had significant effects on prey richness. The three main species contributing to prey biomass across all variables and samples were American sand lance (*Ammodytes americanus)*, summer flounder (*Paralichthys dentatus*), and winter flounder (*Pseudopleuronectes americanus*), with Atlantic cod only making up 0.3% of the total biomass. These data support the hypothesis that grey seals in New England are not contributing to a decrease in the cod population, an important commercial target species, and indicate that other factors need to be examined to explain the decline in major fish populations.

The acoustic repertoire of wild Araguaian river dolphins, Inia araguaiaensis

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The recently described Araguaian river dolphin, *Inia araguaiaensis*, is present only in the Tocantins-Araguaia River Basin in Brazil. The first vocal repertoire description of this species only analyzed sounds produced by one group of known, human-habituated individuals in the Lower Tocantins River. However, a wider survey of this species is needed to evaluate the species' repertoire. Here we report new sounds produced by Araguaian botos. We conducted boat surveys between the mouth of the Tocantins River (1°33'33.05"S 48°50'36.28"W) and the city of Marabá (5°19'35.41"S 48°50'36.28"W). We recorded 482 calls using a high frequency Sound Trap. During each encounter, we noted group size and composition, behavioural state, habitat type, presence of boats and fishing gear. To categorize signals produced by wild Araguaian botos, we extracted parameters of the fundamental frequency as well as measurements of noisiness, Wiener entropy and harmonicity using the bioacoustics software Luscinia. We used a dynamic time-warping analysis to compare sounds and subjected the resulting dissimilarity matrices to statistical analyses (NMDS and UPGMA clusters). In addition to previously described repertoire features, we identified several novel call types in our recordings. These were predominantly tonal sounds: whistles, stereotyped downsweeps, sequences of short (<100ms) tonals, and unusually high-frequency whistles with maximum frequency up to 74 kHz and harmonics up to 150 kHz. Preliminary observations suggest that these sounds are associated with large groups (8-20 individuals) engaged in social behaviour, when surface displays such as individual and synchronized leaps and exhibition of flippers and flukes are frequent. Our results show that investigating a larger set of contexts in wild river dolphins gives a more comprehensive overview of their acoustic repertoire, allowing us to passively monitor their behaviour and distribution in the future.

Photo-identification and movements of bottlenose dolphins in the waters around Sicily (Italy).

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The abundance estimates and movements of Mediterranean bottlenose dolphins living along the Italian coast have not yet been determined, although different photo-identification efforts have been reported. Here we present information on bottlenose dolphin photographic recaptures across six different areas along the coast of Sicily based on data collected between 1997 and 2018 by different research organizations. Specifically, we compared images for 42 dolphins identified in the Aeolian Archipelago (northern-eastern Sicily; Catalogue A), 25 dolphins identified in the Strait of Messina (eastern Sicily; Catalogue B), 103 dolphins identified along the Mazara coast (western Sicily; Catalogue C), 47 dolphins identified along the Agrigento coast (south-western Sicily; Catalogue D), 27 dolphins identified in the waters nearby Catania (eastern Sicily; Catalogue E) and 83 dolphins identified around the Island of Lampedusa (southern Sicily; Catalogue F). We found only 12 matches among catalogues, an average (± SD) of 0.8 ± 2.5 matches for pair ranging from 2-10 matches for pair. Particularly, we found 10 matches between C and D catalogues, which are neighboring areas, suggesting that some dolphins may move across the coastline both in the western and south-western of Sicily. We also found 2 matches between the A and B catalogues, suggesting some seasonal movements, most likely for feeding purposes, from areas in the Aeolian Archipelago and those in the nearest coast of Sicily and/or the Strait of Messina. These results support previous findings showing that Mediterranean bottlenose dolphins tend to aggregate primarily with individuals coming from the same sub-area and only few animals roam widely connecting with different subgroups living in distant areas. The few matches found in this study suggest that geographically isolated bottlenose dolphins might remain within relatively small areas, where they exhibit specialized behavior and feeding habits and face a high risk of local extirpation.

Skies with limits: Optimising Unmanned Aerial Vehicles (UAVs) as a marine mammal survey tool for remote and challenging environments – a Welsh case study.

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Conservation, management and policy surrounding marine mammals are dependent on monitoring population levels, behaviour, disturbance and their habitats. Lightweight Unmanned Aerial Vehicles (UAVs), or drones, have become an important and reliable survey tool for successful data capture and are replacing traditional survey applications. Until recently, marine mammal monitoring surveys have focussed on time and resource intensive manned aircraft, land or boat-based observation surveys. In the last decade, UAV technology, applications and accessibility has improved dramatically, revolutionising traditional surveying techniques, not only within the marine mammal field, but enhancing cross-disciplinary research and into the wider science and regulatory community.

In order to better inform the scientific community, regulatory bodies and policies for conservation and management, it is important to examine the challenges and applications associated with using UAVs within the marine mammal field. In this study we examine common challenges and opportunities associated with using different UAV types i.e. fixed-wing Vs multi-copter UAVs, in monitoring and surveying pinniped and cetacean populations and habitats in remote and challenging coastal areas of Wales. Particular challenges discussed are associated with: (i) UAV deployment, (ii) location, (iii) UAV type, (iv) weather, (v) regulatory limitations, and, (vi) flight operations. Here, we share our knowledge to the scientific community and regulators surrounding potential barriers and considerations to improve survey design to ensure efficient data capture and develop mitigation measures for future UAV marine mammal studies in coastal regions.

It also considers future UAV application opportunities and advances within the marine mammal research field such as: remote sample collection, photogrammetry and camera types, and highlights our UAV marine mammal associated research within Wales.

First scientific field research and citizen science for bottlenose dolphin conservation in the Calabrian (Italy) Ionian Sea.

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Many studies demonstrated that protection through the institution of a marine protected area (MPA) can be effective for marine mammals resulting in the improvement of their survival. Cetaceans are impacted by different anthropogenic pressures and particularly bottlenose dolphins (*Tursiops truncatus*), the subject of this study, suffer from multiple pressures due to their preference in coastal waters. As this vulnerable species is protected under the European Habitat Directive and various other conventions (Bern, Barcellona, Bonn) and agreements (ACCOBAMS), it requires MPAs (such as SCIs - Sites of Community Importance and SACs -Special Areas of Conservation) for their protection. Bottlenose dolphin research and citizen science carried out in the stretch of the Ionian Sea, between Brancaleone and Botricello, is necessary as there is still a gap in knowledge in this region on the presence and distribution of cetacean species. This first year-long study has been developed through the regional operational program 2014-2020, 6.5.a.1- sub-action 2 "Conserving, restoring and protecting habitats and species of the Natura 2000", funded by EU FESR – FSE for the Calabria Region. The project involves a multi-action approach including scientific field research in order to study the distribution and the habitat used by the dolphins; a citizen science approach in order to increase knowledge and awareness regarding the marine environment and dolphins conservation; removal of the marine litter in the SCI *Fondali di Staletti*, in order to reduce the negative impact these could have on the health of the bottlenose dolphins (entrapment in abandoned fishing ghost nets, plastic ingestion, etc.). Preliminary results on the presence and distribution of the bottlenose dolphins is presented. This project contributes towards effective conservation management efforts for the bottlenose dolphin, in a geographic area that is under-investigated despite presence of this species as demonstrated by past stranding events and citizen sightings.

Exposure of marine mammals to noise pollution in the Northeast Atlantic.

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Evidence of adverse impacts to marine mammals from underwater noise pollution has grown rapidly in recent years, including indirect mortality, permanent and temporary hearing impairment, behavioural responses, physiological stress, and acoustic masking of communication signals. To understand the risk of impact, many governments and intergovernmental organisations have begun monitoring and assessing levels of noise pollution in their waters. In some cases, high-level commitments have been made to ensure that noise pollution is at levels which do not harm marine ecosystems.

In the Northeast Atlantic, countries coordinate marine environmental policy through the OSPAR Convention, and since 2015 an impulsive noise registry has been recording relevant noise-generating human activities (explosions, seismic surveys, pile driving, sonar and acoustic deterrent devices) in OSPAR waters. Joint monitoring programmes have also been established to measure and map levels of shipping noise in the North Sea and Northeast Atlantic.

In this study, we build on this monitoring effort to combine maps of the pressure from underwater noise pollution with the distributions of marine mammal species in the region. We present risk maps which highlight the areas of greatest risk for exposure to impulsive and continuous (i.e. shipping) noise for a range of marine mammal species, and areas of relatively low risk. We then demonstrate how quantitative noise exposure indicators can be derived from these maps, enabling the management of cumulative levels of noise pollution according to the predicted risk to marine mammal populations.

Kogia conundrum: Variability in the acoustic signals of dwarf and pygmy sperm whales in deep water.

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Dwarf and pygmy sperm whales (Kogiids) are found throughout the world's tropical and temperate oceans, but because of their small size and cryptic nature much of what is known about the two species is based on strandings. Recent recordings in the presence of both pygmy and dwarf sperm whales indicate it is possible to reliably acoustically identify the clade; however, variability in signal characters across recordings suggested additional work was needed. We used Kogia recordings collected in various locations, depths and with different instrumentation to examine the source of the signal variability. Data from four deepwater sources, including a cabled instrument observatory (MARS) at 900 m in Monterey Bay, CA, a click-detecting deepwater instrument (C-POD F) and a High-frequency Acoustic Recording Package (HARP) on a mooring at 750 m off Hawai'i, and drifting buoys (DASBRs) with a 2-element hydrophone array at 150 m in the Hawaiian Islands and Mariana Archipelago. Narrow-band, high frequency (NBHF) clicks were detected on all instruments, and we are confident in identifying them as Kogiid signals because there are no other deep-diving, NBHF species at these locations. Collectively, these data have consistent centroid/peak frequencies of 115-125 kHz, lower than that known from recordings of dwarf sperm whales near the surface. Encounters contain a mix of clicks with narrow and wider bandwidth, with a portion of clicks detected at all sites containing energy below 100 kHz, another characteristic not seen on surface recordings. Recordings from the DASBR vertical array provide evidence of a dive profile with a 45 minute dive cycle, including clicks detected both above and below the array. Variation in click characters detected at deep vs. shallow instruments does not appear to be related to the recording hardware or recording location, with propagation or behavioral factors the most likely cause of spectral variability.

Maternal foraging trip durations: Establishing a monitoring index of prey availability for the northern fur seal.

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Since 1998, the Pribilof Islands population of northern fur seals (Callorhinus ursinus) has been in decline with variation observed between islands [St. George (STG) & St. Paul Islands (SNP), Alaska]. Maternal females from groupings of breeding rookeries (rookery complexes) forage in

geographically distinct habitats, primarily on walleye pollock. Females alternate between visits ashore to nurse pups and feeding trips at sea, the duration of which [maternal foraging trip duration (MFTD)], is an indicator of foraging condition (e.g. prey availability). This study aimed to identify variation in MFTD at the rookery level (averaged across females) across the lactation period and determine if that variation could explain observed population trends between islands. Between 2010 – 2018, 264 females at six rookeries were tagged with VHF radio transmitters to monitor individual MFTD. Data was used to examine whether longer MFTDs were associated with negative trends in population and if unfavorable foraging conditions – reduced pollock biomass and increased ocean temperature – were associated with increased MFTD aggregated by rookery complex using resource selection functions (RSF). Average MFTD was shorter for STG than SNP females; population indices show a declining SNP but relatively stable STG populations. Amongst the STG rookeries, animals from the SG-North complex made slightly longer seasonally-averaged foraging trips than those from SG-South. Because MFTD varied by complex, MFTD may be most appropriately used to understand conditions of the local marine environment at the rookery-complex level. At the SP-East complex, RSFs explained variation in MFTD in the early portion of the season (74%) but not later in the summer/fall. Early season MFTD was shorter in years where pollock biomass was greater, and surprisingly when surface temperature was warmer. Because MFTD varied with trends in population, it may serve as a population-level monitoring index of prey availability related to the foraging environment.

Interactions between short-finned pilot whales (Globicephala macrorhynchus) and the Atlantic Pelagic Longline Fishery in the Cape Hatteras Special Research Area (CHSRA) off Cape Hatteras, USA.

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Short-finned pilot whales (*Globicephala macrorhynchus*) are susceptible to bycatch in the Atlantic Pelagic Longline (PLL) fishery along the east coast of the United States. The National Marine Fisheries Service (NMFS) estimates that, on average, interactions between pilot whales and the PLL fishery resulted in 192 serious injuries or mortalities annually between 2010 and 2014. This level of mortality is above the Potential Biological Removal level for this stock of pilot whales, which is 159. In 2009, the Atlantic Longline Take Reduction Team recommended establishment of the Cape Hatteras Special Research Area (CHSRA) in response to a high rate of interactions between pilot whales and the PLL fishery in this area of the shelf break off Cape Hatteras. Our goal was to assess the overlap between pilot whales and PLL fishing effort in the CHSRA using the tracks of 57 pilot whales tagged off Cape Hatteras and the distribution of PLL fishing effort from logbook records provided by the Southeast Fisheries Science Center (SEFSC). We analyzed spatial and temporal overlap between the fishery and pilot whales in the CHSRA between May of 2014 and December of 2016. During the spring, summer and fall, pilot whales and the PLL fishery both occur frequently in the CHSRA. Kernel density analyses showed that approximately 70% of the CHSRA can be considered an area of high overlap between pilot whales and the PLL fishery. Our study highlights the importance of the CHSRA as an area likely to continue to present high rates of interactions between pilot whales and the pelagic longline fishery.

Socio-economic incentives for vaquita conservation: Unrealized opportunities and daunting challenges.

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Nearing extinction, the world's smallest porpoise numbers less than 22 individuals. Mexico's vaquita (Phocoena sinus) faces one primary threat – entanglement in gillnets. Although gillnet fisheries are currently banned by the Mexican government in the range of the vaquita, illegal fishing with gillnets threatens the survival of the species. Illegal fishing is motivated by high prices paid in China for the swim bladders of the endangered fish, totoaba (Totoaba macdonaldi), and by a lack of legal permits for alternative gear for other fisheries. We describe efforts and challenges encountered in establishing viable alternative fishing gears and

economic livelihoods for the local communities when neither fisheries management nor enforcement are effective in combating illegal activities. Approaches that support fishers willing to use alternative gears can be a complementary and effective incentive-based conservation tool if efforts are made to establish market connections with buyers and chefs interested in "vaquita-friendly" products. We describe a supply-chain approach and market data analyses, which reveal potential increases in net earnings are possible when consumers share costs of conservation. We use a machine-learning method, Random Forest, to analyze seafood price data from the primary market of southern California for shrimp from the Upper Gulf. A three-year, stratified random sample was collected from 72 locations (28%) of retail markets in San Diego County (n = 6938 shrimp product observations). Analyses revealed the most important price determinant was access to high value markets coupled with the large-size class shrimp found only in vaquita's range. Additionally, eco-labeled products can increase marketplace prices by 12.7-43.7%, thereby offering evidence of the potential benefits of an incentivizing approach. Reliance on enforcement alone cannot abate the lucrative illegal trade for totoaba swim bladders; a new system of compliance with communities is needed. However, any approach to saving the vaquita requires eliminating gillnets throughout their

Combined stable isotopes and tracking analyses reveal an environmental-driven change in the females southern elephant seals foraging strategies

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The Kerguelen southern elephant seal (SES) population underwent a drastic decline in the 1970-1980s, thought to be caused mainly by modifications in the Antarctic ecosystem structure. In the context of global change, the Southern Ocean (SO) is expected to undergo major oceanographic changes (e.g. frontal shifts, sea-ice seasonality, thickness and extent variability). Considering that female SES have two major foraging strategies (interfrontal zone *versus* Antarctic), it raises the question of whether this population will experience new environmental constraints, and if that will lead to changes in foraging strategies over time. To answer this question, ~100 SES pups were blood-sampled and weighed each year at the same site over 13 years (2006-2018). Stable isotopes analysis (SIA) of carbon and nitrogen was conducted on blood samples from the pups to determine foraging strategies of their mothers. This information was related to the pup's weaning weight - a proxy of reproductive success. $\delta^{15}N$ reflects the trophic level at which individuals feed, whereas $\delta^{13}C$ reflects their foraging latitude, which is specific to the SO. SIA revealed no significant change in $\delta^{15}N$, but a decrease in $\delta^{13}C$ over time. This means either that more SES females are using the Antarctic strategy, or that their prey are moving northwards. 96 tracks (2006-2017; 3-16 ind. per year) of post-moult females were analyzed to better quantify potential changes in latitudinal distribution. There is no clear trend over time. However, when splitting the dataset into two periods (2006-2011 and 2012-2017), the Antarctic strategy becomes more prevalent. These results show for the first time a change in the relative proportions of foraging strategies displayed by females SES over time, and may highlight a restructuring of the SO trophic web.

Individual foraging variation drives social organization in bottlenose dolphins.

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Identifying foraging variation within a population and assessing its relationship with social structure is essential to increase knowledge about the evolution of social systems. Here, we investigated individual foraging variation in bottlenose dolphins and its potential influence on their social organization. We used generalized association indices and applied social network analysis to data collected over 4 consecutive years of research in a coastal area subject to significant use and pressure

by humans. Our findings revealed variation in foraging behavior among individual bottlenose dolphins, which in turn shapes their social organization. We demonstrated that bottlenose dolphins preferred to affiliate with other individuals with similar foraging strategies (i.e. homophily). Our results also indicated that individuals that regularly foraged within human-altered areas exhibited denser and longer-lasting associations. These bottlenose dolphins profit from a reliable and easily located food source which may increase their energy intake. We suggest that these individuals could benefit from increased cooperation and reduced intragroup competition, which is likely to facilitate social learning processes related to the development and maintenance of efficient foraging strategies in this human-altered environment. We further propose that these foraging strategies may be perpetuated by both horizontal and vertical transmission of information between individuals. Additionally, the observed homophily could promote, through time, a segregation of the population into behaviorally distinct groups. These findings provide valuable insight into the evolution of bottlenose dolphin social systems and their response to human-induced changes in the marine environment.

Using citizen science to assess migration patterns of humpback whales in Australia.

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Globally, baleen whales have been recognised to undergo changes in migration, behaviour and health and these shifts have been attributed to climate change in some cases. These changes raise concerns over the future of whale recovery even for populations that have reached near pre-whaling numbers. Detecting such changes requires long-term data and detailed observations over large spatial scales. However, migratory species like humpbacks whales (*Megaptera novaeangliae*) are difficult to monitor due to their vast home ranges. Acquiring extensive datasets on these animals can be expensive and time consuming. We have compiled a large data set comprising of a minimum of species, number of animals and sighting location with some data including calf sightings and behaviour categories for Australian coastal waters. The data set contained over 100 000 entries covering up to 25 years of observation. The majority of this data originated from citizen science projects. We have assessed the data for suitability of detailed analyses. A spatial and temporal representation of the sightings suggests that breeding grounds, migratory corridors and resting areas are covered. Migratory patterns and number of calves sighted were compared between regions showing similar trends between the east and west coast of Australia. However, collection methods and effort varied greatly between data sets and required standardisation. A number of standards and rules were identified that would improve the value of citizen science data and make it more comparable for future research projects. Overall, we conclude that large-scale data sets derived from citizen science projects can assist in predicting future movement and populations of humpback whales.

Evaluation of the immune response in the threatened Australian sea lion using novel technologies: qPCR and ddPCR

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The Australian sea lion, *Neophoca cinerea*, is listed as endangered (IUCN Red List, 2008) and ongoing population declines have been identified due to a number of factors including the species' breeding life history and anthropogenic disturbances. More recently, disease in pups was identified as a threat contributing to population declines. In two South Australian colonies, Seal Bay and Dangerous Reef, hookworm infection (*Uncinaria sanguinis*) affects 100% of neonatal pups causing high morbidity and mortality. Novel approaches in pinniped immunology will help to pave the way for understanding mechanisms that affect survival after infection and improving management decisions when new disease arise. In order to address key knowledge gaps for the species in relation to immunocompetence, quantitative PCR (qPCR) primers were designed and optimised for the detection of relative gene expression of pro-inflammatory (Il-6, TNFα) and regulatory cytokines (IL-10, IFNg, IL4) in *N. cinerea*. As field limitations precluded the use of lymphocyte stimulation assays, samples were collected into RNAlater for subsequent analysis of natural cytokine expression. Despite high qPCR efficiency, samples from *N. cinerea* pups frequently produced qPCR Ct values approaching or below quantifiable limits, suggesting the need for the development of more sensitive methods for detection.

Here we describe the development and utility of the novel molecular biology technique, droplet digital PCR (ddPCR), as a highly precise, more sensitive

and reliable method for measuring cytokines of *N. cinerea* that by the current gold standard methodology, qPCR, are too low or impossible to detect. The application of novel methodologies such as ddPCR, which requires lower sample volumes and provides absolute quantification of immune markers, provides greater insights into managing populations resilience in the face of endemic and emerging diseases and population decline. These methodologies can be applied to both individual and population health investigations in *N. cinerea* and other threatened pinniped species.

Harbour porpoises in the southern North Sea – seasonal migration from East to West?

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In the German Bight, harbour porpoise (Phocoena phocoena) occurrence is perennial, however, the distribution is fluctuating, indicating a seasonal migration pattern. Related to wind farm construction in the German Bight (including adjacent Dutch waters) passive acoustic monitoring devices (porpoise detectors, C-PODs) were deployed and digital aerial surveys conducted. We analysed information from 130 C-POD locations in the German Bight on 79,384 recording days from 2010 to 2016 and compared the findings to porpoise distribution patterns derived from 172 aerial surveys from 2014 to 2016. To identify habitat-driven regional differences in the German Bight, we clustered C-POD positions into four subareas. Clustering of C-POD locations was based on temporally static variables (e.g. water depth, distance to shipping lane). It resulted in 4 subareas: the eastern German Bight, the southwestern German Bight (including adjacent Dutch waters), the northeastern German Bight, and the central German Bight. Porpoises were distributed most evenly during winter, when porpoise activity was similar throughout the subareas. During all other seasons, porpoises were less common in the central German Bight, compared to the other subareas. Especially in summer, the northeastern subarea was characterised by high porpoise activity. The annual pattern in this subarea was clearly distinctive, showing a maximum of porpoise activity in summer and a minimum in the winter months. In contrast, the central German Bight showed a maximum in porpoise activity in winter and a minimum in summer. Throughout the German Bight a shift from high porpoise activity in summer in the eastern German Bight to high porpoise activity in winter in the southwestern German Bight including adjacent Dutch waters was visible both in C-POD and flight data. Our findings are an indication for seasonal porpoise migration from the eastern German Bight in summer to the western German Bight in winter.

Bite me: Using cookie-cutter shark bite scars to estimate age of Blainville's beaked whales in Hawaiian waters.

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Beaked whales (family Ziphiidae) make up almost a quarter of all cetaceans. However, with the exception of a few species taken in whaling operations, little is known of their life history, ecology or population structure, due primarily to their offshore distribution and long dives. Blainville's beaked whales (*Mesoplodon densirostris*) have been studied extensively around the main Hawaiian Islands and a long-term photo-identification catalog has revealed a small resident population off Hawai'i Island. Adult individuals in this population have large numbers of scars from cookie-cutter shark (*Isistius spp.*) bites, and such scars remain visible for up to at least 21 years, aiding in identifying individuals. To determine whether scar acquisition rates could successfully predict age, we compared age estimates derived exclusively from scarring to those from a photo identification catalog using a sample of 18 whales seen over long time spans (median=8.5, max=19.6 years). A standardized area three times the length and the height of the dorsal fin centered beneath the fin was assessed for sightings of individuals with good or excellent quality photos where the full area of interest was visible. We both quantified the total number of scars and the area of the scars measured within the polygon. Of the two methods, individual scar acquisition rates produced more realistic age estimates than changes in scarring areas, due to overlap among bites over time. Acquisition rates will be used to estimate age when individuals were first encountered to derive estimates of longevity and sexual maturity (i.e., age first seen with a calf for females or tooth eruption for males). Possible age-related and individual variability in scar acquisition rates need to be explored to better

assess the utility of this method, however it shows promise as a way to better understand life history and population dynamics of this species.

Initial results of Antillean manatee (Trichechus manatus) milk microbiome

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Microbiome in milk is an essential component calf growth of a healthy gut microniome. Previous studies on milk microbiome on different mammals (humans, cows, otters) have found a high variety of bacteria, including *Staphylococcus epidermidis, Bifidobacterium longum, Clostridium sp,* and *Clostridium coccoides.* The aim of this study was to describe the microbiome on Antillean manatee milk in order to develop techniques to improve nutrition of manatee calves rescue and under human care, particularly in the Caribbean and South America. Milk DNA was obtained from 4 lactating females, three in México and one in Colombia. Milk was treated with saline solution to allow separation of fat, followed by DNA extraction with a commercial kit. DNA was then used for library preparation and whole shotgun genome sequencing was done on an Illumina platform. 22.343.699 reads were generated and read quality was assessed using Fastqc followed by analyses in Qiime 2 and Mothur pipelines on Galaxy to identify OTUs. Among 19.349.392 unique reads aligned with 16s available databases, 111 OTUs were identified. All OTUs belonged to Bacteria, with similar groups found in each of the four samples. Phylums Proteobacteria (90%) and Firmicutes (10%) were detected. Among Proteobacteria, Enterobacteriales were the most common class found (32%), followed by Pseudomonadales (31%) and Aeromonadales (25%). Class Bacili was the most common among Firmicutes. Alpha diversity indexes were similar to values reported for human and cow milk (Shannon Index SI= 4.67 ± 0.13; Simpson Index = 0.0016 ± 0.0011; Chao = 484.15 ± 255). These milk samples are also being researched, used with traditional microbiologic techniques in order to identify which of these bacteria could be grown to produce nutritional and probiotic supplements for manatees under human care.

Community outreach as a tool for Antillean manatee conservation in Puerto Rico

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Antillean manatees are endangered in Puerto Rico initially from extensive hunting, but today due to watercrafts collisions, habitat degradation and encroachment. While research and government management efforts have existed since the late 1970s, and intensified during the past 30 years, conservation efforts must include a community component to be effective. With this in mind, we have developed an extensive community outreach campaign to address public knowledge and the role they can play into contributing directly to manatee conservation. These public efforts include the distribution of printed materials, a public service announcement campaign, and an active presence in the web and social networks, in addition to participating in local environmental activities and receiving visitors at our Manatee Conservation Center. The guided tours, given by volunteers and interns, allow visitors to see firsthand the active conservation efforts on behalf of the species and helps inspire them to become active in their respective day-to-day to preserve and care for manatees, the ocean and the environment. Parallel to this, the Center was instrumental in 2013 in the enactment of a Puerto Rico law that declares the manatee as Puerto Rico's national mammal and established the 7th of September as the "Day for the Conservation of the Caribbean Manatee." During the past years, over 1,000 teachers were trained and 148,650 students celebrated this day with different environmental

activities in their own school and communities. All together, these varied community outreach and education efforts have increased over the years; the sum of all during the past 5 years is some 17,513,459 people impacted. Academic research and government management guide recovery efforts for endangered species, such as the manatee, but its true recovery from endangerment can only be secured if the community is involved and their detrimental habits are turned towards positive conservation behaviors though education.

Temporal patterns of humpback whale non-song calls on their Newfoundland foraging grounds

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While animal signals convey information intra- and interspecifically, their adaptive importance is often unknown. Humpback whales (*Megaptera novaeangliae*) of all sexes and age classes produce non-song calls on their foraging grounds; however, little is known about these calls and their function. As a first step to investigate their function, the temporal patterns (daily, weekly, annually) in non-song call activity of humpback whales were examined on their Newfoundland foraging grounds – an understudied area – from July-August, 2015-2017. During each year, continuous 24-h recordings of non-song calls were collected using a hydrophone moored within a key spawning area of their main fish prey species (capelin, *Mallotus villosus*). Whale abundance and capelin biomass were quantified weekly via ship-based surveys. Acoustic recordings were aurally/visually surveyed in Raven Pro 1.5 to identify the date and time of non-song calls, and calls were subsequently classified into broad classes (i.e., high frequency, low frequency, pulsed, compound call). Call activity for all call classes was consistently higher during light relative to dark periods across all days in all years, suggesting that communication and/or foraging occur less during dark periods. Additionally, call activity varied daily within and across years, associated with varying capelin biomass. While the precise function of non-song calls remains unclear, preliminary research highlights their importance and common occurrence during daylight behaviours, potentially for foraging. Thus, comparing humpback whale call activity to density of their main prey species in this high-latitude foraging grounds allowed varying prey availability to be connected with patterns in non-song call activity, thereby providing further insight into the context of these non-song calls.

Clear response of seals to acoustic deterrence sounds using on-animal sound and movement recording tags

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Few studies are available on behavioural responses of wild seals to underwater noise. Among the few, are Acoustic Harassment Devices (AHD) or 'seal-scarers' that are used for deterrence around fish farms, but also for mitigation of hearing damage prior to anthropogenic activities producing intense underwater sound. These studies have typically only been able to monitor the distance between animals and AHD or their presence/absence. To learn about the behavioural responses of individual seals, we deployed long-duration sound and movement recording tags (DTAG-4) on harbour seals (*Phoca vitulina*) in Limfjorden, a semi-enclosed fjord in Denmark. AHDs are not commonly used in Danish fisheries and the seals were thus presumably naive to the sound. Four animals were tagged with DTAGs and VHF transmitters. After a minimum of 48 hours after tagging, they were then re-located at sea and exposed to the AHD for one hour. Repeated exposures of the same animal (maximum three) were separated by 1-7 days. All seals experienced an initial sound pressure level of $L_{eq125ms}$ in excess of 140 dB re 1 µ Pa, and all showed clear responses, indicating that the response threshold was below this level. Responses were evident as changes in dive behaviour and acceleration. Three out of four animals exhibited increased stroke rate throughout the one-hour exposure period while received levels dropped, indicating that the seals swam away. One animal with a detailed GPS track moved away from the sound source to a distance of 4 km within the exposure period, considerably further than reported in other AHD exposure studies. Habituation between exposures was not observed. Exposure levels recorded on the DTAGs deviated up to 20 dB from predicted levels based on on-site measurements and propagation modelling, illustrating the importance of on-animal sound recordings during exposure studies in shallow water habitats with complex sound propagation.

The underwater soundscape of fear: Behavioural responses of cetaceans to naval sonar and playback of predatory killer whale sounds.

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The risk-disturbance hypothesis proposes that anthropogenic sounds may be perceived by animals as a threat similar to predator presence, driving individuals to trade fitness-enhancing behaviours such as foraging for perceived safety. We tested this hypothesis by quantifying how cessation-of-feeding responses to playbacks of mammal-feeding killer whale (kw) sounds (at natural source levels of 150-160 dB re1µPam) of four cetacean species in Norwegian waters (long-finned pilot, N=11; humpback, N=11, sperm, N=17 and bottlenose N=4 whales) corresponded to responses during separate experimental exposures to 1-4 kHz naval sonar (max source levels of 214 dB re1µPam). Using species-specific movement and/or echolocation click production parameters recorded on suction-cup attached Dtags, we quantitatively distinguished dive types (intense-active foraging vs non-foraging and exploratory behaviour) using hidden Markov models. Across species intense foraging time was lower during both predator playbacks ($p<0.001$) and sonar exposures ($p<0.001$), compared to pre-exposure baseline periods, while no effect of broadband noise ($p>0.9$) or vessel-only (no-sonar) control exposures ($p>0.2$) was found (Generalized estimating equations Wald test). The mean proportional reduction to kw playback and sonar correlated strongly across species ($r^2=0.93$, n=4), though there was notable variation across individuals. Bottlenose whales responded most strongly with a 100% reduction in foraging during both stimuli types, followed by humpback (97% for kw playback, 80% for sonar) and long-finned pilot whales (~75% both stimuli). The least responsive species was sperm whales, which reduced intense foraging time by ~50% during both stimuli types. This strong correspondence in reductions of intense foraging provides clear support for the risk-disturbance hypothesis. The low-frequency specialist humpback whale had an intermediate level of response to sonar compared to the higher-frequency odontocetes. We conclude that the risk of disturbance from anthropogenic sounds may be better predicted by a species' underlying vulnerability to predation than its hearing sensitivity relative to the sonar band.

Instantaneous stamp tattoo: A refined marking method in Phocid seals.

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Wildlife research often involves marking animals to facilitate the collection of data specific to individuals over time. Minimising the short- and long-term effects of marking on the animal's behaviour and health is not only imperative for animal welfare, but ensures that the data collected can be perceived as natural, with little or no effect from the identification mark/tag.

Here we describe the first documented use of an instantaneous stamp tattoo as a marking method in phocid seals and assess its efficacy and impact.

Short term captive grey (*Halichoerus grypus*), n=11, and harbour seals (*Phoca vitulina*), n=3, held at the Sea Mammal Research Unit Pool Facility, were marked with an instantaneous tattoo, under anaesthesia, during handling for associated procedures. Uniquely identifying marks were applied to the hind flipper webbing using modified ear tattoo pliers, 7mm alphanumeric stamps and tattoo ink. The application of the tattoo was carried out in seconds and the procedure had a negligible impact on the animal. The equipment used is portable and the application process required minimal training.

Images of the tattoos were taken during subsequent handling events and tattoo marks scored for impact and efficacy. The longest duration between mark application and imaging was 132 days. All tattoo marks became less defined over time but remained obvious and readable. There was no health complications or damage to the tissue as a result of the instantaneous tattoo.

The initial evidence from this study shows that this marking technique is effective for phocid seals, has no impact on the animals' anatomy, physiology and their ability to perform natural behaviours. Although this study was relatively short in duration and longer testing is required to

confirm the durability of marks, it demonstrates a refinement of marking method and should be considered as an alternative to current methods.

Monitoring the abundance of common bottlenose dolphins in Vis archipelago (Central Adriatic Sea, Croatia)

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Data on the occurrence of the common bottlenose dolphin (*Tursiops truncatus*) within a study area centred around Vis Island (Adriatic Sea, Croatia) has been collected during summer seasons from 2007 to 2018. We used this long-term photo-identification dataset to obtain annual abundance estimates and test for a trend in abundance. Boat-based surveys resulted in a total of 13,673 km of research effort in favourable weather conditions. There was a total of 660 encounters with bottlenose dolphins in this period, from which 1060 sufficiently distinctive individuals were identified. Annual abundance estimates were calculated using the mark-recapture closed population model and the Mth estimator of Chao. These were then corrected for the proportion of non-distinctive individuals. The resulting corrected estimates ranged from a minimum of 353 (95% CI: 287-483) to a maximum of 600 individuals (95% CI: 462-866). The annual variations in abundance are possibly attributable to non-uniform research effort or habitat use patterns of the studied community, rather than actual changes. This is corroborated by the regression analysis results which did not indicate a statistically significant trend in annual abundance. The bottlenose dolphin community in the study area appears to have been stable within the reported period. This data contributes to informed management of the SCI for bottlenose dolphins (HR3000469) which is part of the chosen study area.

Stranding monitoring program in Brazilian coast: Analysis of reports.

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Marine mammals stranding occurs worldwide due to natural and human-related factors. In Brazil there are many different activities that can negatively impact marine mammals. Fishing is important to many people, yet impacts from fisheries on marine mammals are still difficult to measure. Oil and Gas Industry is another relevant sector that can affect negatively the animals. Pre-salt oil region exploration brought a major concern as it is a huge area where the number of boats has been increasing, besides seismic studies, underwater noise, oil spill, number of ports and others. Some researches are analyzing the impact of this activity on marine mammals in a long term, however no one knows the real impact. As part of Oil and Gas Licensing, governmental environment agency requires the development of environmental programs, including stranding monitoring program (PMP). The main objective of PMP is to collect data to evaluate the interference of hydrocarbons extraction on marine tetrapods. Different institutions are contracted by Oil Companies to execute PMP. Most of them are member of the Stranding Network coordinated by ICMBio/CMA which created a working group to analyze marine mammals reported by PMP in five geographical areas covering 3.388km between Ceará and Santa Catarina State. From 2010-2017 a total of 2.594 individuals stranded. Besides remarkable spatial-temporal variation in mortality and the overall high number of stranded animals, the most immediate issue is the stranding of 1.325 Guiana Dolphin (*Sotalia guianensis*) and 1.234 Franciscana (*Pontoporia blainvillei*) individuals, classified as EN and CR in the National List of Endangered Species, respectively. Together, both species represented 70,14% of the total recorded mortality. The stranding majorities occurred in the months August, September and December in the Northeast coast, and between June to October in the South. The analysis provided important overview of marine mammal information for management and conservation actions.

Abundance estimate of beaked whales (Family Ziphiidae) in the Canary Islands from a distance line transect acoustic survey.

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The Canary Islands archipelago (Spain) is one of few places in the world where beaked whales (Ziphiidae) are known to occur year-round. These deep-water cetaceans are especially vulnerable to acoustic pollution and affected by other human impacts also, such as ship-strikes or debris ingestion, which cause strandings at the archipelago. However, there are no data on the local abundance of Ziphiid species to evaluate their conservation status. This study reports the first abundance estimate of the family Ziphiidae in the Canary Islands, derived from a line-transect acoustic *Distance* survey performed using a stereo towed hydrophone array in autumn-winter 2009-2010; this resulted in 99 transects totalling 3030 km length. Acoustic detections of beaked whale clicks were extracted and processed in *PamGuard* software to obtain perpendicular distances of the whales to the transect line, horizontal distances correction assuming animal depths from DTAG data was applied to reduce bias. *Distance Sampling* methods were applied to estimate absolute abundance within the sampled area of 52933 km^2 including the national territorial waters. A previously estimated $g(0)= 0.3$ was applied to correct for the availability bias. AIC criteria selected a hazard-rate model without adjustment terms as the best model for the detection function, with an effective detection distance of 500 meters. The detection function was estimated using 104 event detections. The best density estimate is 0.013 beaked whales/km^2 (95% CI 0.005 – 0.026), and the best abundance estimate is 688 (95% CI 311 – 1386) individuals for the survey area. This study provides a starting point for future work to monitor the status and population dynamics of beaked whales in the Canary Islands, essential for the conservation management of the species.

Tracking northern fur seal migrations using 14C in whiskers and satellite tags.

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Northern fur seals (*Callorhinus ursinus*; NFS) breed on the islands mainly in the Okhotsk Sea (Tyuleny and Kuril islands), and the Bering Sea (Commander and Pribilof islands) during June–August. Overwintering NFS makes southward migration, and in the past decade, they have been reported to interact with coastal fisheries along the Hokkaido coast of the Sea of Japan. Previous studies using flipper tags suggest that NFS overwintering in the Sea of Japan was from islands in the Okhotsk Sea and the Bering Sea, however, there is little information after the population in the Pribilof islands has depleted. In this study, we aimed to reveal migration patterns of NFS from the Sea of Japan by using radiocarbon (14C) and satellite tags. In Japanese waters, cold Oyashio Current with low Δ14C flows southward along the Kuril islands, through Pacific coast of northern Japan. And warm Kuroshio Current with high Δ14C run northward along the Pacific coast of Japan. The Tsushima Current, split from the Kuroshio Current, flows from into the Sea of Japan. Therefore, analyzing whiskers of NFS can produce sequential records of habitat use. We attached satellite tags on 5 NFSs caught off the coast of Hokkaido, and sampled whiskers in 2017. Each whisker was sectioned from root to tip, and used for 14C analysis. Two tags transmitted long enough to reach breeding islands, Commander islands. Δ14C values in whiskers showed several oscillations with the lowest values (-40 ~ -50‰), which may indicate values in the Bering Sea, and with the highest values (10 ~ 20‰), which may reflect the values in the Sea of Japan. Therefore, it is suggested that NFS traveld back and forth between the Bering Sea and the Sea of Japan. The combination of bio-logging and chemical tracers enabled us to track individual long-term migration.

Science, law and marine mammals - analysis of a complex relationship and review of the legal framework in place to protect marine mammals in the UK.

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The relationship between science and law is complicated for a number of reasons, including:

- Scientific knowledge is uncertain, open to revision in light of new evidence and tends to advance more quickly than law;
- Science deals with uncertainty in ways that do not match legal systems; and
- Law is frequently limited to a particular jurisdiction, whereas scientific subjects are often transboundary in nature.

Marine mammal research is advancing rapidly, with technological developments (e.g. animal-borne sensors and processing of big data) enabling scientists to learn more about their subjects than previously. Many marine mammal populations, however, remain data deficient with a lack of knowledge of their biology (e.g. distribution, abundance and life history) and conservation status. In addition, there will also be statistical uncertainty.

The UK has more than twenty species of marine mammals living in its waters and a number of legal frameworks protecting them. Extensive scientific research has been undertaken in the UK for many decades. Despite the wealth of knowledge this has provided there is no UK legislation dedicated to the protection of marine mammals. Instead, there is a legal patchwork, with some legislation decades old and initially established to protect terrestrial species and habitats.

This presentation will analyse the difficulties in reconciling science and law and the role of scientific research in the creation and implementation of a legal framework for marine mammals. It will further review the effectiveness of UK legislation and the challenges of ensuring strict protection under the Conservation of Offshore Marine Habitats and Species Regulations 2017 and the Conservation of Habitats and Species Regulations 2017. In particular it will consider the difficulties in enforcing offences such as deliberate disturbance and intentional or reckless damage or destruction of habitats, together with the implications of such enforcement, or potential lack of, going forward.

Euthanasia of an adult humpback whale (Megaptera novaeangliae) in South Brazil.

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Live whale strandings are always challenging and when rescue is not possible, euthanasia is a choice to be considered. IWC recognizes mechanical and chemical methods for large whale euthanasia and here we describe a successful procedure in an adult humpback whale that stranded in Solidão Beach/RS (-30.57497;-50,38458). On 27th February the authors were informed about a live stranded humpback whale. It was 12.7m long, estimated 20tons of weight, had corneal, palpebral and pain reflexes, could follow people with eyes and was vocalizing. As it had half of the body buried in the sand, was considered in poor body condition and beach conditions did not allow any kind of safe rescue, the staff decided for euthanasia. Animal was monitored by the staff and drugs for euthanasia were acquired. In an adaptation of published protocols to the available drugs, on 2nd March we decided for the following protocol: 1-local block with lidocain, small incision on dorsal bubbler for best access to the epaxial muscle. 2-IM injection of midazolam (0,05 mg/Kg), acepromazine (0,25mg/Kg), cetamin (2,47 mg/Kg). 3-IM injection of xylazine (2,5mg/Kg). 4-after reflex loss, local block with lidocaine and intracardiac injection of KCl (200mg/Kg). After 20 min of the first IM injection, the animal started to show nystagmus and had lowered palpebral reflex. Xylazine administration was performed after 40 min of the start of the procedure and leaded to palpebral reflex loss. We did a local block, the manufactured stainless steel needle was inserted just behind right pectoral fin insertion and KCL was administrated in the heart. The animal stopped breathing just after the start of KCL administration. After 40min after the last breath, the animal was considered dead. Although there are published papers about chemical euthanasia in large whales, every case is unique and has new important information to be shared.

Establishment of fibroblast cell lines and induction of pluripotent stem cells derived from four-finned dolphin Tursiops truncatus

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【Objective】 In 2006, one common bottlenose dolphin Tursiops truncatus having a pair of pelvic fins was found and kept alive. It was expected to

elucidate the molecular mechanism of loss/regeneration of pelvic fins of cetacean and unveil the mystery how they lost their hind limbs during their evolution through the research of the four-finned dolphin. Unfortunately, this dolphin died without generating offspring. Here, we focused our studies on establishments of (1) cell lines derived from the four-finned dolphin fibroblasts to conserve its genome resources, and (2) induced pluripotent stem (iPS) cells to utilize them for various studies.

【Methods】 (1) Four-finned dolphin fibroblasts were cultured and infected with recombinant lentivirus encoding immortalizing factor SV40T or hTERT. These lentivirus also have a blasticidin S-resistance gene. In infection experiments, either individually or mixed virus solutions were used. Two days after transfection, blasticidin S was added to select infected cells. (2) Four-finned dolphin cell lines were co-transfected by electroporation with human derived reprogramming factors Oct3/4, Sox2, L-Myc, Klf4, Lin28. A week after electroporation, these cells were re-seeded on feeder cells and cultured for 3 weeks. Also, we are trying to construct vectors encoding dolphin derived reprogramming factors.

【Results】 (1) Blasticidin S-resistance cells were obtained under conditions with SV40T alone, or mixture of SV40T and hTERT. These cells have replicated past the Hayflick limit. Then, we collected single cell clones and made growth curves. All transfected clones showed remarkable increases in growth rate compared to the non-transfected cells. Also, SV40T expression was detected from these clones by Western blotting. (2) A month after electroporation, iPS cell-like colonies appeared. In addition, these colonies showed positive reactions by ALP staining suggesting that these colonies may be in a de-differentiated state.

Historical distribution of whales in the Eastern North Pacific based on data from the US Whale Discovery Marking Program, 1962-1969.

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Between 1962 and 1969, the US whale Discovery marking program conducted 14 exploratory research cruises, mostly in winter months. The surveys ranged from northern California to the southern tip of Baja California, east to mainland Mexico and west to the Revillagigedo Archipelago. Winter surveys in these areas were and remain uncommon. Data from these cruises provide rare insights on historical winter distribution of whales.

During these cruises, 991 groups of whales were sighted, including one group of right whales, 514 groups of gray whales (approximately 6 whales marked, no recoveries), 70 groups of humpback whales (44 marked, no recoveries), 73 groups of minke whales, 74 groups of Bryde's whales (19 marked, no recoveries),31 groups of sei whales (12 marked, 2 recoveries), 79 groups of fin whales (56 marked, 11 recoveries),73 groups of blue whales (84 marked, no recoveries), 54 groups of sperm whales (176 marked, 7 recoveries), and 17 groups of killer whales. There were also five sightings of a species similar in size to Bryde's and sei whales, seen in a mixing area for these species, which the experienced observers (DWR, KCB) found difficult to identify. Based on field descriptions, they may have been Omura's whales.

Gray and fin whales were seen throughout the entire area surveyed. Humpback whales were seen in different areas off Baja California seasonally. Minke whales were not seen in the lower third of Baja California but were seen in southern areas offshore. Sperm whales were mostly seen north of Baja California. Blue whales were seen in large numbers off Baja California in winter. Sei whales were seen north of the southern third of Baja California and Bryde's whales were seen in the middle and southern areas of Baja California, although never sighted north of 26° N. Killer whales were seen sporadically along the entire coast.whale

Comparisons and relationships of genetic characteristics of Japanese harbour seals in eastern Hokkaido between breeding and non-breeding seasons.

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In Japan, harbour seals inhabit the Pacific side of Hokkaido, and major breeding grounds are located in four administrative districts: Erimo, Akkeshi, Hamanaka and Nemuro. Breeding site in Erimo is

150km away from the closest site in Akkeshi, while each breeding ground in Akkeshi, Hamanaka and Nemuro are separated by 20km. Japanese harbour seals are known to disperse in non-breeding season but come back to the same breeding site in subsequent years. The past population genetic studies using mtDNA and microsatellite markers suggested they are separated into two populations; Erimo and eastern Hokkaido. The eastern Hokkaido is strongly affected by the gene flow from the north east, where currently much larger breeding ground is located (>1000). In this study, we compared the genetic characteristics of eastern Hokkaido harbour seals divided into four groups; Akkeshi-breeding, Hamanaka-breeding and Nemuro-breeding and non-breeding, to see how the immigration from the north east affect the breeding groups in eastern Hokkaido. Genetic differentiation was observed only between Hamanaka-breeding and non-breeding for microsatellite Fst ($p<0.05$). MtDNA marker on the other hand suggested population differentiation between Hamanaka-breeding and Akkeshi-breeding for Fst ($p<0.05$), and Hamanaka-breeding and non-breeding for both Fst ($p<0.05$) andΦst ($p<0.01$). PCA analysis indicated only the second axis was significant ($p<0.01$) which accounted for 41.39%. Hamanaka and Akkeshi-breeding were genetically the farthest away while Nemuro-breeding and non-breeding showed genetic similarities. Our result based on both mtDNA and microsatellite markers supported seals breed in Hamanaka has the largest genetic differentiation compared to the other groups, suggesting the seals here are least affected by the immigration from the north east, making them subgroup in eastern Hokkaido. Furthermore, this study suggested importance in sampling seasons for understanding the relationships of subgroups of harbour seals within population.

Efficacy of using acoustic alarms on gillnets to reduce harbour porpoise bycatch in Norwegian fisheries

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Incidental takes in gillnets is the most serious global threat to harbour porpoise (*Phocoena phocoena*) populations. In Norway, the incidental mortality due to bycatches is about 3000 porpoises per year. Ten small fishing vessels operating in the Norwegian coastal zone targeting cod (*Gadus morhua*), saithe (*Pollachius virens*) and monkfish (*Lophius piscatorius*) were used in multiple season-long field trials to determine the potential of acoustic alarms (pingers) mounted on gillnets to reduce incidental takes (bycatch) of harbour porpoises. We collected catch and bycatch data for a total of 50 000 net-weeks. A total of 17 porpoises were taken, distributed with 11, 1, and 5 porpoises in the cod, saithe and monkfish fisheries, respectively. Our analyses show that the efficacy of the pingers was 70% in the cod fishery, 100% in the monkfish fishery and 100% in the saithe fishery. We conclude that pingers can potentially bring harbour porpoise bycatch in Norwegian fisheries well into sustainable levels. However, the fishers reported that they had to take extra care in handling nets with pingers to avoid damaging or entangling the pingers. The conservation benefits of pinger use for the harbour porpoise must be balanced against economical and practical considerations due to an extra time and work cost of handling gillnets with pingers attached. The pingers also contribute to anthropogenic underwater noise that displaces porpoises away from preferred habitats. We propose that a partial, rather than a full-scale, pinger deployment strategy should be used in a area/time targeted fashion to reduce expected bycatch to some predetermined, sustainable level.

Relative abundance of humpback whales in Maui Nui--preliminary results of 2019-20 aerial surveys.

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Evidence from 2016-2018 suggested that the Hawaiian humpback whale distinct population segment may be in decline. Earlier aerial surveys (1993-2003) of the main Hawaiian Islands showed the wintering population to be increasing at a rate of 7% per year, with highest densities in the Maui Nui (Maui, Molokai, Kahoolawe and Lanai) and Penguin Bank regions. The goal of 2019-20 aerial surveys is to replicate that earlier effort to detect changes in relative abundance and/or distribution in the latter high density areas. The first year's results (2019) are reported here.

Surveys were performed from a twin-engine Partenavia P68 aircraft flying at an altitude of 244 m (800 ft) and a speed of 100 knots. Tracklines consisted of north-south systematic lines spaced 14 nmi apart, extending 7 nmi past the 1000-fathom depth with random lines connecting endpoints. GPS, altitude, distance from the trackline, group size and presence of a calf were collected for each sighting. Survey

crew consisted of a data recorder and two observers, one on each side of the aircraft.

Surveys were conducted on dates to correspond to peak whale densities (Feb. 8, 18 and March 1) based on prior surveys. A total of 174 whales were sighted across 1,709 km effort for an overall encounter rate (ER) of 0.102 whales/km. ERs from earlier surveys ranged from 0.062 in 1993 to 0.101 in 2003. Despite earlier evidence of a rapidly increasing population, the 2019 ER was equivalent to that in 2003. The percent of groups containing a calf was higher in 2019 (9.2%) than that seen earlier (from 5.2% in 1995 to 8.6% in 2003). Thus, the 2019 surveys presented conflicting evidence regarding the current status of the wintering population in the Maui Nui region necessitating additional state-wide surveys.

In vitro evaluation of cytotoxic and genotoxic effects of Di(2-ethylhexyl)-phthalate (DEHP) on bottlenose dolphin (Tursiops truncatus) skin cell line

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Cetaceans are long living species, that occupy different trophic levels in the food chain. Most cetaceans are wide ranging, showing seasonal movements and changes in habitat use, which can be very variable even at individual level. Due to their position at the top of the food chain, the low rate of their metabolism and the presence of a layer of blubber, which accumulates lipophilic pollutants, cetaceans bioaccumulate high quantities of marine contaminants. For these reasons, cetaceans are considered good indicators of the status of marine waters. In more recent years, several studies have associated the death of many of these organisms to the ingestion of marine litter, mainly constituted by plastic debris, which can become a major source of pollutants. Di(2-ethylhexyl)-phthalate (DEHP) is the most abundantly used plastic additive and it has been reported to affect multiple biochemical processes both in humans and wildlife. Nevertheless, there is limited information on the toxicological effects of DEHP on marine organisms, in general, and on cetaceans, in particular. In this study, we evaluated the cytotoxic and genotoxic effects of DEHP on Bottlenose dolphin skin cell line, employing specific *in vitro* tests to assess cell viability and DNA damage. Cytotoxicity tests showed a slight dose-response decrease of cell viability after 24 h of exposure to DEHP. Genotoxicity tests, such as Comet and Cytokinesis-Block MicroNucleus (CBMN), detected only a slight increase of DNA strand breaks but a clear indication of a significant micronucleus induction after treatments. The overall results demonstrate that *in vitro* exposure to DEHP has cytotoxic and genotoxic effects on Bottlenose dolphin skin cell line. Moreover, these results are discussed in comparison to DEHP effects detected on the standardized Chinese Hamster Ovary cell line (CHO).

The Navy Acoustic Effects Model (NAEMO): Adapting to Changing Requirements.

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The Navy Acoustic Effects Model (NAEMO) was developed in 2008 to assess the potential level of behavioral disturbance and physiological impacts (e.g., temporary and permanent threshold shifts) for individual marine mammals and sea turtles likely to be in the vicinity of Navy training and testing activities. Recent updates to NAEMO include a web-based data collection system and the continual incorporation of the best available scientific data (e.g., marine species density and distribution data, updated acoustic impact criteria and thresholds). NAEMO has been adapted to consider different output requirements based on the level of analysis required, such as analyzing groups of species (i.e., stocks or guilds) instead of only assessing potential impacts at the individual species level. As NAEMO enters its fourth generation of software, the Navy is evaluating how to adapt the inputs and apply analytics to account for future regulatory requests or requirements. Potential enhancements may include analyzing how density layers are used in the model, examining the number of simulations required for densely or sparsely populated species, increasing the complexity of the event being

modeled, increasing resolution in environmental data, accounting for the effects of moving animals, incorporating potential mitigation and avoidance, and developing additional statistics to inform results. These prospective changes will be explored considering the best available science and evaluated to determine their potential to better understand the acoustic impact of Navy activities on marine species.

Genomic estimates of effective population size for blue whales.

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Estimation of effective population size (Ne) and abundance (census size, Nc) remains challenging to derive for wildlife species, particularly for those with wide ranging distributions, high mobility and cryptic behaviours. Ne and Nc are key parameters for the conservation and management of wildlife because they can determine the degree to which populations are at risk. While Nc impacts demographic and ecological processes, Ne affects genetic drift, loss of genetic diversity and levels of inbreeding. Genetic methods have recently gained popularity for estimating Ne due to the development of various statistical approaches, and the availability of user-friendly software. Blue whales (*Balaenoptera musculus*) were reduced to very low numbers during the whaling era, with some subspecies and populations impacted more heavily than others. Here we estimate contemporary Ne for populations of three blue whale subspecies (*B. m. musculus*, *B. m. intermedia*, and *B. m. brevicauda*) using a single-sample estimator based on the Linkage Disequilibrium (LD) method, and a panel of >15,000 unlinked single nucleotide polymorphism (SNP) loci. Samples (n= 277) originated from Antarctica, Eastern South Indian, Western South Pacific, Eastern North Pacific, Eastern Tropical Pacific, and Eastern South Pacific. Population genomic analysis in general indicated higher differentiation and low contemporary migration rates between subspecies, and lower differentiation and moderate migration rates between populations within subspecies. Ne estimates ranged from 43 to 455 (mean= 240, SD= 140), depending on the population, and Ne/Nc (for populations with Nc estimates available) ranged from 2 to 41% (mean= 0.20, SD= 0.17). Simulations indicated that factors impacting robustness of estimates include migration rates, strength of bottlenecks, sample sizes and scheme, and choice of parameters for estimation. This study identifies issues to be considered when planning genomic estimates of Ne for cetacean populations, and assists in interpreting estimates within a conservation management context.

Updating a photo-id catalog of bottlenose dolphin off Catania.

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Updating a photo-id catalog of bottlenose dolphin off Catania.

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To fill the gap of data on presence, distribution and social interactions of cetaceans off the coast of Catania, after a decade of interruption of the photo-identification works in the Gulf of Catania (Ionian Sea, Italy), the Marecamp association decided to update an existing old catalog of dorsal fin of bottlenose dolphins living in the area (Monaco et al., 2010). The visual method of Würsig & Würsig and the computer-assisted programs DARWIN (Stanley, 1995) and SOCPROG were used (Whitehead, 2009).

The old catalog contained 39 individuals identified from 1997 to 2008 while the new one permitted to update many reference photos of 3 previous classified specimens and also to add new items, reaching 49 bottlenose dolphins photo-identified until 2018. We collected 320 new photos during 2 hours of sighting overall, for a total effort of 90 hours of monitoring.

According to fission-fusion grouping patterns typical of medium size bottlenose dolphins' herds, we saw some confirmed individuals of the catalog maintain relationships between them, while other individuals, confirmed matches and not, established new social associations, moving North-South and back across the Gulf.

Using mark-recapture principles for population study and observing the high slope of the discovery curve, we found that the investigated population has not been still completely identified. Moreover, ongoing studies with some Sicilian organizations are conducting in order to verify any old and/or new relationships with specimens from adjacent areas to the Gulf and to better comprehend population dynamics.

Using U.S. law to protect endangered marine mammals from entanglement and promote ropeless fishing gear.

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The U.S. Endangered Species Act (ESA) has been described as the most comprehensive legislation for the preservation of endangered species ever enacted by any nation. The ESA is expressly designed to prevent extinction and promote recovery of imperiled species.

We will provide a brief overview of how the ESA works. We will highlight a case study of entanglements of large whales in fishing gear off the U.S. West Coast and how the powerful ESA was brought to bear on the whale entanglement problem.

We will describe how reported entanglements of large whales began increasing in 2014, breaking historical records each of the past four years. Preliminary data from the U.S. National Marine Fisheries Service indicate that at least 45 whale entanglements were reported in 2018. The data show that there were 71 reported large whale entanglements in 2017, up from 62 in 2015 and 30 in 2014. Before that, whale entanglement reports averaged fewer than 10 per year. We will briefly describe suspected causes of the increase in entanglements, including climate change, shifting fishing effort, and increasing whale populations.

We will also describe how, in 2019, use of the ESA, resulted in a time area closure to protect whales during their migration, plans to adopt a science-based risk assessment management program, and incentives to develop and adopt ropeless fishing gear.

Effects of limited dispersal by sea otters (Enhydra lutris) on population dynamics; Relevance to the threatened Southwest Alaska distinct population segment.

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Small, isolated populations with limited dispersal capabilities are demographically independent at relatively small spatial scales, and at risk of demographic and genetic constraints to sustainability. Our data from across Alaska indicate that densities and trajectories of sea otters differ among regions separated by <100km. The Southwest Alaska stock of sea otters presents an interesting case, having experienced two discrete population reductions, and understanding population health and sustainability is important, given the Threatened status of the stock. Sea otters were hunted to near extinction in the 18th and 19th centuries, with just 2 remnant colonies surviving in the western Aleutian Islands. Population recovery over the 20th century was slow due to their limited dispersal capabilities and high site-fidelity, but by 1985 sea otters had recolonized most of their former habitat in the western Aleutians. Beginning in the late 1980's, the Southwest Alaska stock suffered another major population reduction (~90%) due to killer whale (*Orcinus orca*) predation. In contrast to pre-decline distributions, the remaining sea otters are concentrated in a few colonies that occur in sheltered habitats. This distribution likely protects them from predation, however the patchy distribution combined with high fidelity likely acts to reduce demographic

connectivity among colonies. We use data from surveys and tagging studies to parameterize a spatial model of population connectivity before and after the recent population decline. We hypothesize that predation-driven selection for reduced movements and high fidelity to sheltered habitats will lead to reduced gene flow and further losses of genetic diversity due to small population sizes. Ultimately, the limited dispersal capabilities of sea otters in combination with predation by killer whales may have implications for the long-term viability of sea otters in the western Aleutian Islands. Management strategies that increase gene flow and maintain remnant genetic diversity should be considered.

Temporal trends in mortality patterns of the endangered franciscana dolphin (Pontoporia blainvillei) in southern Brazil

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The franciscana (*Pontoporia blainvillei*) is endemic to the western South Atlantic Ocean and the most threatened cetacean species in South America mainly due to the bycatch in gillnet fisheries. In the coast of Rio Grande do Sul, Southern Brazil, the overlap between franciscana distribution and gillnet fleets results in a high bycatch rate resulting in thousands of stranded franciscanas along the beach. In 2012, the Brazilian Government published a norm to regulate gillnet fisheries by reducing the fishing effort and establishing no-fishing zones. Consequently, a decrease in bycatch and stranding rates of franciscanas should be expected in most recent years. Generalized Additive Models (GAM) with a time series of five years before (2008-2012) and five years after (2014-2018) the publication of the norm were used to evaluate the temporal stranding patterns. Bycatch data collected by onboard observers in commercial fishing vessels were used to estimate the mortality during the white croaker (*Micropogonias furnieri*) and striped weakfish (*Cynoscion guatucupa*) fishing seasons, from 2013-2015 and 2018-2019 using Hierarchical Bayesian models. The stranding rate showed a slight and non-significant decline after 2012 ($p=0.19$). The strandings were highly seasonal with peaks from November to February which coincided with a higher gillnet fishing effort for the white croaker. The estimated number (Mean; [Credible Interval]) of franciscanas killed in the croaker season ranged from 93[6; 2014] in 2015 to 574 [83; 1157] in 2018. For the weakfish season, the estimated number ranged from 259 [16; 591] in 2015 to 508 [85; 988] in 2018. Current levels of fishing-related mortality of franciscanas are similar to previously reported estimations (i.e. before the norm), thus are still very high and may not be sustainable. Long-term monitoring of incidental captures through on-board observers and beach surveys are essential to evaluate trends in this mortality and to guide management actions.

Marine mammals matter: Combining applied research with education to inspire community conservation action.

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Education is key to empowering community and individual capacity to undertake effective conservation and sustainability management within marine environments. With an increasing amount of research dedicated to the impact of plastic and marine debris in marine mammals, such as entanglements and ingestion, it is important to raise awareness to promote positive change. As marine mammalogists we have a unique ability and responsibility to educate the community, foster environmental connection through compassion of whales, dolphins and seals, and empower and inspire action towards a better tomorrow. From communities living in close proximity to coastal environments to those that are geographically distant, understanding key ecological processes, anthropogenic threats and influences, and management and mitigation are important factors in the application of community conservation initiatives. The Marine Mammal Foundation is a not-for-profit research, education, and conservation organisation. With our wide range of education programs, community outreach programs, and citizen science activities, we are uniquely placed to combine applied research with action for conservation and understanding of south-east Australian marine environments. We highlight innovative outreach and education programs that together have reached over 18,832 community members (2017-2019). From curriculum-based school incursions bringing real research into the classroom; litter mitigation programs *Marine Litter Project*, *Bin Not Bay* and *Litter Free Lakes*; community citizen science program *Lakes*

Champions, to our youth empowerment program *Marine Champions*, these crucial initiatives aim to connect, empower and create change. The outcomes include raising awareness of local marine mammals; highlighting impacts of anthropogenic threats such as recreational boating and litter and marine debris; strategies to mitigate threats; encourage youth participation in applied science; and empower individual and community conservation and sustainability action. Volunteer contribution, collaboration between industry, community groups, and other stakeholder organisations, and ongoing funding support has proved vital in the successful implementation of not-for-profit education and outreach programs.

Sonic seas: Hearing abilities of an endangered Cook Inlet beluga, in situ noise measurements and implications for masking.

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Cook Inlet belugas (CIBs) are a critically endangered and declining marine mammal population. Anthropogenic noise is considered a primary threat to these animals and sound is critical to key behaviors including communication, foraging, and navigation. Yet there have been no data on hearing in CIB, making it challenging to quantify noise-related impacts. In the fall of 2017, a beluga calf from the endangered CIB population stranded and as part of its health assessment we measured its hearing in October and December using evoked potentials. The beluga calf heard all frequencies tested (4-120 kHz) and showed sensitive hearing (<70 dB) for a wide range of frequencies (16-80 kHz), reflective of a healthy odontocete auditory system and similar to many healthy belugas from the Bristol Bay population (the only other published data set of healthy, wild marine mammal hearing). October and December measurements were similar, showing continued auditory health of the animal throughout the stranding rehabilitation. Hearing data were compared to noise measurements made in Cook Inlet from two primary sources of concern at ecologically relevant locations: pile driving (ca. 4km distance from source) in Cook Inlet and container-ship noise several km from the stranding site. Despite being measured relatively far from the source, noise spectra (in 1/3 octave bands) were substantially higher than the hearing thresholds, suggesting masking is often likely even at 'mid-frequencies' (4-11 kHz) in the communication range and at ecologically relevant distances. Overall, these data provide the first empirical hearing data for a CIB allowing for estimations of sound-sensitivity in this population. Sensitive hearing and ambient soundscape data show noise is a clear concern for this population, and provides important baseline knowledge to better address environmental concerns related to the lack of recovery for the endangered CIB population, and general increase of underwater noise in the Arctic.

The 2018 California Current Ecosystem Survey: A multi-disciplinary assessment of predators and prey off southern Canada, the USA and northern Mexico.

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NOAA Southwest Fisheries Science Center (SWFSC) conducted the California Current Ecosystem Survey (CCES) from June – December 2018. Made possible by the Pacific Marine Assessment Program for Protected Species (PacMAPPS) – a partnership between NOAA, the US Navy, and the Bureau of Ocean Energy Management – this ambitious and first-of-its-kind multi-disciplinary survey encompassed waters from Vancouver Island, Canada, to southern Baja California, Mexico, out to 200 nautical miles offshore. This was the 8th large-scale marine mammal and ecosystem survey of the California Current conducted by SWFSC since 1991; however, it was the largest of these in its latitudinal

scope, and in addition to the standard large-vessel visual line- and strip-transect abundance and distribution surveys for cetaceans and seabirds, it also included data collection by drifting acoustic spar buoy recorders (DASBRs) for deep diving cetaceans; continuous acoustic backscatter for prey species; and – in collaboration with Cascadia Research Collective – an unprecedented biopsy sampling and photographic identification effort for humpback and other baleen whales. The cetacean sighting rate was twice that of any previous survey, almost certainly because survey effort was more heavily concentrated over the continental shelf than for past surveys. The NOAA large vessel working together with the Cascadia small-boat facilitated us collecting hundreds of biopsies and thousands of identification photographs. CCES data will be used to update and improve marine mammal stock assessments for the California Current, and additionally, to update cetacean density maps, address trophic ecology questions (predator-prey distributions), improve fishery stock and integrated ecosystem assessments (prey consumption estimates), provide greatly improved population size estimates for beaked and sperm whales, and provide stock-delineation and population biology inferences for humpback whales to inform management associated with high numbers of entanglements in pot and trap fishing gear.

Thermal infrared detection of peri-callosity heat loss, core temperature and subsurface movement in surfacing and skim feeding north Atlantic right whales.

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Study of right and bowhead whale thermoregulation has been limited primarily to descriptions of substantial but variable blubber thickness, and of the corpus cavernosum maxillaris (oral rete), a blood-filled erectile sponge, that has been suggested to provide heat loss and avoid cerebral hyperthermia. Here we describe unmanned aerial system infrared thermography of surfacing, and surface and subsurface skim feeding North Atlantic right whales (*Eubalaena glacialis*). Epithelial surfaces adjacent to keratinized rostral callosities are warmer than the callosity keratin and post-cranial epithelium, especially for individuals whose rostra remain above the water surface during skim feeding. The thicker callosity tissue and overlying cyamids may act to insulate heat radiation from callosities. Anatomical examination of the dermis and hypodermis in these areas in samples from a ship struck specimen showed no obvious large blood vessels, or other retial structures. Thus, we suggest that these warm areas may show dorsal radiation of heat from the oral rete. Dorsal views of open blowholes also show very significant heat, suggesting that suitably calibrated vertical images will allow for measurement of core temperature, as described previously for the bottlenose dolphin (*Tursiops truncatus*). Thermal infrared imagery of subsurface swimming right whales can also allow for tracking, by observing upwelling of colder, deeper water during fluke upstrokes. Additionally, one animal showed a large patch of post cranial heat radiating dorsally in the thoracic area, suggestive of underlying pathology. We suggest that this technique could be developed to enable quantitation of core temperature, and rostral heat radiation in different behavioral, acoustic stress, and environmental conditions, providing an acute term assay of thermal response to diverse stressors. Entangled and emaciated animals, and those with healing scars could also be examined using this technique to better understand the effect of these stressors on both local lesions and core temperature. NOAA Permit 17355-01.

The effect of marine traffic on bottlenose dolphin (Tursiops truncatus) behavior in The Ría de Arousa in Galicia, Spain.

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Understanding the dynamics between bottlenose dolphin (*Tursiops truncatus*) behavior and anthropogenic behavior is essential for the creation and implementation of effective conservation strategies for the species. Due to a general trend towards coastal urbanization, bottlenose dolphins encounter frequent disturbances due to human activities, facing increased threats to fitness and survival. This study examined the effects of marine vessel traffic on a resident population of bottlenose dolphins in the Ría de Arousa of Galicia, Spain. Marine vessel traffic, specifically commercial mussel farm boats, fishing boats, and tourist

catamarans, is the most common anthropogenic threat faced by the Ría's dolphins. Using land-based observations, data were collected on group behavior and marine vessels interacting with a group. These data were used to compare differences in behavioral transitions, behavioral budgets, and bout durations in the presence and absence of marine vessel interactions. The Ría's resident bottlenose dolphin population was more likely to continue traveling and less likely to remain resting in the presence of marine vessel traffic. The behavioral budget analyses indicated they also spent a higher proportion of time traveling and a lower proportion resting. The average length of behavioral bouts was significantly different in impact situations, during which dolphins experienced longer traveling and socializing bouts and shorter resting bouts. These short-term consequences may result in long-term decreases in reproductive success and survival at the individual and population levels. Thus, steps should be taken to improve local legislation and increase public awareness with the goal of conserving this resident population of bottlenose dolphins.

Identifying important habitat for endangered northern bottlenose whales along the Scotian Shelf in eastern Canada.

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The Scotian Shelf population of northern bottlenose whales (*Hyperoodon ampullatus*) comprises fewer than 150 individuals, occupying the shelf edge and submarine canyons off eastern Canada. The population is listed as Endangered under Canada's *Species at Risk Act*, and three noncontiguous areas encompassing the Gully, Shortland, and Haldimand canyons located offshore of Nova Scotia are currently designated as critical habitat. The inter-canyon slope areas separating these critical habitats are rarely surveyed, and there are few reliable sightings of northern bottlenose whales outside the canyons in this region. Here, we combined alternate sources of data to infer the habitat use and movements of northern bottlenose whales within and between designated critical habitat areas. Passive acoustic monitoring conducted with bottom-mounted recorders over a two-year period revealed the presence and foraging activity of northern bottlenose whales in inter-canyon slope areas throughout the year, with a seasonal peak in acoustic detections during the spring. Towed hydrophone array surveys also confirmed species presence in these areas. Photo-identification data collected during encounters with northern bottlenose whales inside the three canyons were used to model residency and movement patterns within and between canyons, based on the lagged identification rate of individuals with unique and reliable markings. Individuals regularly moved between canyons over periods of days to months and also spent time outside of the canyons. Together, these results indicate that inter-canyon areas along the continental slope comprise important foraging habitat for northern bottlenose whales and function as corridors for frequent movement between the core habitat areas within the canyons. This study demonstrates how year-round passive acoustic monitoring combined with photo-identification-based movement modelling can be used to examine habitat use in areas with limited visual survey effort.

Photographic identification of long-finned pilot whales (Globicephala melas) in the Pelagos Sanctuary

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Photo-identification is a method of using photographs of natural markings, such as scars and pigmentation patterns, to identify individuals. The study area where photographs of long-finned pilot whales (*Globicephala melas*) were collected is the North-West Mediterranean Sea from 1999 to 2017. The sampling effort was being mostly carried out in the Pelagos Sanctuary (marine protected area for cetaceans since 1999) with a total of 18 surveys and more than 30 hours of observation at sea. The photo identification process carried out for this project was based on natural markers described in the following publications: Sergeant and Fisher (1957), Sergeant (1962a), Kastelein et al. (1990), Gowans and Whitehead (2001). To describe the distribution and abundance of the marks along the flank and the dorsal fin, each mark type found in the photographs was analysed. During the 12 years of sampling (from 2006 to 2017), 18 sightings of long finned pilot whales occurred, and 8211 photos of Globicephala melas were collected and 161 individual of long finned pilot whales were identified with photos of different quality rating. Among these 161 individuals, only one is a calf, all the others are adults or sub-adults. Parameters related to the left side and the right side, was calculated analysing individuals with Quality

Rating ≥1 (the best): 83 individuals for left sides, 115 individuals for right sides. Analysis revealed the presence of 1337 marks. In general, from the data obtained is possible to assert that the right side is more injured than the left side, indeed the right side present 791 total marks compared to the 546 of left side. On the basis of this injuries was possible establish the frequency of recapture from which showed that the 20% were photographically captured (recaptures) more than once.

Remote sensing of polar bears using aerial multispectral imagery

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Instrument-based aerial surveys have proved to be an efficient approach to estimating broadly distributed populations of ice-associated seals by increasing survey range, decreasing disturbance of animals, and reducing error relative to surveys with human observers. Automating data collection and image processing increases efficiency of the survey and post processing of collected imagery. Despite the success of detecting seals on ice, reliability of detecting polar bears has remained uncertain. During 2016 surveys of the Chukchi Sea, long wavelength infra-red (LWIR) imagers were used to detect seals and polar bears on sea ice. Automated thermal detection of bears that were either identified by onboard observers and then flown over to collect imagery, or known to be in the survey strip based on post-flight examination of high-resolution color images, revealed a lower detection rate for polar bears than seals (0.70 and 0.96, respectively). Additionally, just 3 polar bears, much lower than the approximately 10 that were expected, were detected in the effective survey area (5830 km2) yielding a markedly lower abundance estimate than that produced from analysis of capture-recapture records. To investigate the possibility that processes such as heterogeneity or activity could have biased polar bear detection estimates, we used an APH-28 hexacopter drone to collect multispectral imagery of captive bears exhibiting behaviors thought to impact detection by visual observers. Using machine learning modeling techniques and aerial multispectral imagery of wild and captive polar bears, we present an evaluation of polar bear detection in infrared, color, and ultraviolet imagery along with 2016 Chukchi Sea survey results.

Prediction of the cochlear frequency map for the harbor porpoise

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In mammals, the base of the cochlear spiral within the inner ear encodes high frequency sounds, while low frequencies are transduced in the apex. However, the distribution of frequencies along the spiral, also called cochlear frequency map, is species-specific and non-linear. Cochlear frequency maps are not known for cetaceans. The value of these maps is that they can provide information on the causal sources, if lesions are detected in cases of noise-induced hearing loss. Morphometric variation occurs in cells of the organ of Corti (the hearing organ) along the cochlear spiral. These variations in cell shape and spacing can be related to the frequencies encoded at different locations, as shown in the guinea pig. We used geometric morphometric measurements from scanning electron micrographs of the organ of Corti along 10 locations of the cochlear spiral in harbor porpoises, mustached bats, rats, mice and gerbils. We used machine learning algorithms with the morphometric data of echolocating bats and rodents (species with known frequency maps) to identify a predictive model relating morphometry with coding frequency. Then, we used this model to predict the cochlear frequency map for the harbor porpoise. Subsequently, we validated the frequency hearing range of this prediction using the ear of a harbor porpoise whose audiogram was measured. We found that harbor porpoises have a large area of the cochlea that encodes for the same frequencies, which corresponds to the maximum hearing sensitivity for the species. The ability to combine morphological and auditory data is crucial to validate cochlear frequency maps based on morphological features. In addition, we could apply this approach of cochlear mapping for other species and predict hearing range and frequencies of maximum sensitivity in cetaceans whose audiograms are unknown by analyzing the morphometry of the cells of the organ of Corti.

Management strategy evaluation for a feedback regulatory system to limit marine mammal

bycatch: The bottlenose dolphin case-study.
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Bycatch in commercial fisheries is considered a global threat to marine mammals. However, regulatory initiatives to monitor and limit bycatch from commercial fisheries are still limited. The Potential Biological Removal (PBR) and fisheries classification system offers a regulatory framework implemented in the United States' Economic Exclusive Zone to limit bycatch of marine mammals in commercial fisheries. PBR is calculated for each population against which bycatch is compared to classify each commercial fishery as having 'frequent', 'occasional' or 'remote' bycatch. In principle, only fisheries classified as 'frequent' and 'occasional' trigger bycatch management measures. This system is to be applied to fisheries operating outside the US that export fishing products to the US. However, a formal evaluation of the combined management components (PBR and fisheries classification) has not been conducted. In this study, we use a simulation approach (management strategy evaluation; MSE) to determine the performance of the bycatch management system, in particular the proportion of correct and incorrect fishery categorization under scenarios of bycatch (moderate/high), distinctiveness of fishery categories (clearcut/fuzzy) and precision of bycatch and abundance estimates for a population of 10,000 bottlenose dolphins. Correct classification was generally high, in particular for categories that should lead to management measures, i.e. 'frequent' and 'occasional'. Misclassifying 'frequent' as 'remote' and vice-versa rarely occurred, while misclassifying a fishery that is 'remote' as 'occasional' can become common when bycatch is high, an expected outcome for a precautionary system. Unintuitively, the 'remote' to 'occasional' misclassification was exacerbated for clearcut fishery categories, and the effect of precision of bycatch and abundance estimates varied across scenarios. MSE offers a valuable tool to test the robustness of management frameworks aimed to mitigate marine mammal bycatch in commercial fisheries and can be applied to populations with a range of demographics and conservation status.

Data from the dead: New methods extract genetic data from poor-quality samples to breathe life into detecting population structure of harbor porpoise in the Pacific.
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Harbor porpoise in the North Pacific are found in coastal waters from southern California to Japan, but population structure is poorly known outside of a few local areas. The small size and elusive behavior of porpoises make them difficult to biopsy and force reliance on stranded and bycaught carcasses for samples. Samples collected over 40 years from stranded or bycaught animals often yielded poor quality DNA. We used multiplex amplicon sequencing and genotyping clusters of SNPs as microhaplotypes to examine the population genetic structure of harbor porpoise along the coast from California to southern British Columbia. We inferred patterns of population structure using genotypes of 292 microhaplotype markers (271 samples) as well as mitochondrial control region sequences (413 samples). We confirmed an overall pattern of strong isolation-by-distance, suggesting that intergenerational individual dispersal is restricted along the US west coast. We also found evidence of regions where genetic differences are larger than expected based on geographic distance alone, implying current or historical barriers to gene flow. In particular, the southernmost population in California is genetically distinct (F_{ST}=0.02 (microhaplotypes); 0.31 (mtDNA)), with both reduced genetic variability and high frequency of an otherwise rare mtDNA haplotype. At the other end of our study range, we found significant genetic differentiation of samples from the Strait of Georgia, previously identified as a potential biogeographic boundary or contact zone between harbor porpoise populations.

Additional signals of low dispersal and population subdivision along the US West Coast suggest variation among populations requiring species management on a regional scale. Microhaplotype genotyping provided high power to detect genetic structure in harbor porpoises despite reliance on poor-quality samples.

Length of the free-ranging wild Indo-Pacific bottlenose dolphins Tursiops aduncus around Mikura Island determined using an underwater 3D camera.

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The body length of an animal is used to understand its ecology. A decrease in the growth rate of neonates and calves is an alarm for unhealthy conditions of an animal population. In cetaceans, stranded and/or entangled animals are a source of such information. However, in the small oceanic Mikura Island, Japan, there are only a few strandings and entanglements because of lack of beaches and commercial fisheries. Herein, we report the length of the free-ranging wild Indo-Pacific bottlenose dolphins *Tursiops aduncus* around Mikura Island using a simple commercial 3D camera with underwater housing and measurement software (Applied Vision Systems Corp.) to estimate their body length. This system has errors within 5% for the body length. Only the body length of identified dolphins was used in the analysis as almost all dolphins around Mikura Island have been identified using natural marks on the body. There was no difference in body length between four entangled adult (> 13 years old) dolphins and 19 measured adult dolphins (Wilcoxon/Kruskal-Wallis test, $\chi^2 = 0.32$, $p = 0.57$), indicating that the length estimations are actual values. There was no sexual difference in the body length of adults (Wilcoxon/Kruskal-Wallis test, $\chi^2 = 0.83$, $p = 0.36$). Gompertz 3 parameter curve equation (JMP11, SAS Institute, Inc.) was as follows: $L = a * exp(-exp(-b * (age - c)))$; L = length, a = asymptotic line, b = growth rate, and c = inflection point. An analysis of 40 individuals aged 0-30 years (maximum age for study in Mikura Island) of both sexes revealed that $a = 244.9 \pm 3.49$, $b = 0.50 \pm 0.09$, and $c = -0.69 \pm 0.24$. This simple and inexpensive underwater system is important for monitoring dolphin population health.

Echolocation clicks of rough-toothed dolphins (Steno bredanensis) at the South Brazil Bight, South Western Atlantic

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The rough-toothed dolphin (*Steno bredanensis*) occurs throughout tropical and warm-temperate waters worldwide. However, there are few descriptions of the echolocation clicks of the species, and most studies are concentrated in the Pacific Ocean. In Brazil, previous works on their acoustic signals were recorded generally near the coast and reported mostly the whistle descriptive parameters. This work aims to contribute with the acoustic description of the species and to provide more data on their click parameters in the South Atlantic Ocean. Acoustic data was collected during the visual and acoustical vessel-based survey at the 2019 Summer expedition implemented by the Santos Basin Cetacean Monitoring Project (PMC-BS/PETROBRAS). A towed hydrophone array and an acoustic processing system (hydrophones RESON4013, NIDAQ 500kHz and PAMGUARD) were used to monitor the biological signals in real time. The signals were analyzed automatically using the Band Limited Energy Detector of the software Raven Pro 1.5 and manually using a custom LabVIEW based program. A group of approximate 15 dolphins (visual confirmation of group size and species) was recorded on April 3rd, 2019 at a distance of 145 mn from shore (25.1698°S, 41.2942°W) and 2,789 m of depth. An animal was observed with a fish in the mouth, suggesting that the group was foraging. We analyzed 1,018 echolocation clicks of this detection. The preliminary results of 39 minutes of recording presented higher peak (median = 37.10 kHz; range = 14.64 – 72.26 kHz) and center (median = 39.06 kHz; range = 21.48 – 83 kHz,) frequencies than previous described for the Pacific. However, the values were close to another study at the South Western Atlantic. This work is an important step for additional research on the

species in the Atlantic Ocean, contributing to the discussion and understanding of different populations distributed in different ocean basins.

Successful DNA extraction, bisulfite conversion and amplification of baleen whale lamina growth layers in earplugs for use in epigenetic analysis

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Epigenetics is the study of changes in gene expression which does not involve alterations to the underlying DNA sequence; a change in phenotype without a change in genotype. To date, studies of epigenetics have shown that alterations in DNA expression are a regular and natural occurrence influenced by age, environment, and disease states called epigenetic drift. Recent advances in epigenetics have shown drift patterns can provide insight into many biological processes such as aging as well as how environmental pressures influence species. However, to date, there has never been a suitable matrix for extracting a methylation profile over the entire lifespan of a long-lived species. We extracted DNA from annually deposited lamina of baleen whale earplugs, historically used as an aging proxy, using a novel method we developed from modern forensic techniques. From our method, we extracted DNA from < 30 mg of earwax material. DNA underwent bisulfite conversion and amplification for Whole Genome Bisulfite Sequencing for use in downstream analysis. Few epithelial cells are trapped in the waxy tissue, making the DNA difficult to separate from this matrix. Furthermore, Next Generation Sequencing is difficult to perform on extracted DNA due to low starting material from museum samples, the extraction process, and subsequent conversion of the DNA with bisulfite. However, we were able to extract DNA concentrations of < 100 ng for full bisulfite conversion and amplification which we validated with a Quibit Fluorometric Quantificationä measurement. This method will allow for future analysis of epigenetic drift in accordance with aging to assess how baleen whales deal with environmental stress.

Insights into long term harbour porpoise (Phocoena phocoena) strandings monitoring on the west coast UK

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The UK has a statutory obligation under the EU Habitats Directive to report on the conservation status of harbour porpoise (*Phocoena phocoena*) and to quantify threats and pressures at both an individual and population level. Investigation of stranded marine mammals provides unique insights into population demographics, distribution, health and emerging threats - metrics difficult to obtain by other means. We summarise analysis of 25 years of strandings data of harbour porpoise from the entire west coast of the UK and highlight the implications for management.

Analyses used sex and age parameters to explore population structure and identify potential areas of importance for reproduction. Necropsy data on cause of death were examined for spatial and temporal variation in direct-anthropogenic versus other causes of mortality. Nutritional condition of harbour porpoise was characterised as a proxy for assessing spatio-temporal trends in population fitness.

GAMM modelling showed regional differences in seasonality of strandings independent of age specific mortality. More than a quarter of the strandings on the UK west coast occurred in Cardigan Bay, Wales, and this area showed a significantly higher proportion of stranded neonates, possibly indicating an important breeding area. The most common direct anthropogenic cause of death was fisheries bycatch, with notable clusters on the south west coast and during the months of January-March, consistent with known bycatch hotspots for the inshore fishing fleet. Finally, nutritional condition showed no spatiotemporal trends, indicating no significant change in apparent fitness over time.

This analysis has provided a baseline against which future monitoring will be measured and demonstrates the value of this globally important,

long-term programme of strandings monitoring. It has given us key insights into population structure, mortality and anthropogenic pressures of harbour porpoise in the UK, and delivers a strong evidence base for future marine conservation policy.

Dangerous hood? Build trust and prosper: Associations of female bottlenose dolphins (Tursiops truncatus) and their calves in the Southwestern Gulf of Mexico.

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The coastal waters off Alvarado are highly productive and dolphin-fisheries antagonistic interactions are frequent although uncommon in resident individuals due to spatial segregation. Social affiliations in female coastal bottlenose dolphins are often unstable, and commonly involve multiple partners across the years. Conversely, mother-calf pairs last several years, until offspring reach maturity and independence. We studied the dynamics of such associations using 98 photo-id surveys and half weight coefficients of association (HWCA) amongst 103 sexed resident individuals over an eight-year period. We also analyzed the isotopic signatures of $\delta^{13}C$ and $\delta^{15}N$ in dentine formations from growth layer groups (GLG) on five stranded individuals within the study area. From 319 sightings, 45% were all-female, whereas 39% were mixed sex. Overall, 72% of the sightings had fewer than 10 members, and 94% of female groups had less than 7 individuals. HWCA amongst the 73 resident adult females were low (x=0.3, sd=0.06), but stable within the first three months, and decreased exponentially towards the third year. However, eleven females formed long lasting associations (HWCA>0.5) with <3 particular females over time. Also, HWCA values from 20 mother-calf pairs (12 of them with 1-3 offspring) showed high and stable companionships (x=0.5, sd=0.17), that decreased linearly since birth towards the fifth year (r^2=0.99). Furthermore, isotopic signatures in both elements also decreased from the prenatal layer towards the GLG of years 1-2, and increased between the GLG of years 3-5, suggesting feeding independence after the second year of age. Small groups have been related to lower detectability by fishers in this dolphin community. Also, long-lasting associations between known females may help to ease the nursing costs under stressful conditions of harassment by humans and male dolphins. The short nursing period may be a response to the stress produced by the high vessel traffic (x=20 h^{-1}) in the area.

Fine-scale habitat use variation in a common bottlenose dolphin (Tursiops truncatus) population.

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Understanding the physical processes and environmental variables influencing cetacean movements on a small scale is necessary to discern the ways in which these top predators utilize their habitat. In this study we analyze the variables related to the presence of common bottlenose dolphins (*Tursiops truncatus*) in two adjacent but environmentally distinct areas within the Ria De Arousa (Galicia, Spain) using land-based data collection techniques. The first location is a wide, open area of varying water depths and bottom substrates, and the second a more protected, shallow channel leading to an estuarine area characterized by a muddy bottom. Environmental factors driving dolphin presence within each area were modelled using General Additive Models (GAMs). Environmental and dolphin sighting data were collected from January to November 2018 with a total of 359 hours in the field, 191 dolphin sightings and an average of 0.53 sightings/hour. Dolphin presence was significantly different between the two areas (average sighting frequency 1.12 and 0.20 sightings/hour) and dolphins appeared to prefer deeper water and varied bottom substrates. A temporal variation (monthly and circadian), as well as tide level variation in dolphin presence was observed overall and within the wider of the two areas. Within the shallow channel, however, none of the environmental variables measured appeared to significantly influence dolphin presence. This study shows that, even at a small scale, marine top predators are very selective in the way they utilize different areas of their habitat based on different

environmental variables through time. While most cetacean studies are often conducted on very large scales, the scale at which this study was completed allows for a more relevant understanding of a local population of marine top predators, information which is crucial to ensure a tailored and efficient protection and conservation plan.

Importance of the pond inlet-eclipse sound-milne inlet area as nursery and calf-rearing habitat for narwhals (Monodon monoceros)

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The Pond Inlet - Eclipse Sound – Milne Inlet area (Pond Inlet Complex) is traditionally used during summer by one of six narwhal stocks that inhabit the Canadian High Arctic. Although some interchange of animals between summering areas has been documented, most narwhals are thought to return to the same summering area each year. The reasons that narwhals return to the same summering areas is unknown, but possible reasons include to calve, rear young, avoid predators such as killer whales, and feed.

We analyzed digital imagery obtained during aerial surveys conducted in the Pond Inlet Complex during 1 August-22 October 2014 and 1 August-17 September 2015. Imagery was obtained by two DSLR cameras oriented obliquely to either side of the aerial survey trackline. Imagery was reviewed for time periods coinciding with narwhal sightings during the survey and narwhal images were classified as calves, yearlings, other subadults, and adults based on size and colouration. Totals of 4002 and 1993 narwhals were classified in 2014 and 2015, respectively. Numbers of narwhals in each of nine geographic strata were estimated for each survey in each year using observer sightings. Proportions of animals of each size class from analysis of the imagery were extrapolated to each stratum to estimate numbers of calves in each stratum and overall in the Pond Inlet Complex. During aerial surveys of the main summering period from 1 August to 2 September 2014 and 1-31 August 2015, 9.4% and 6.7%, respectively, of narwhals present were estimated to have been calves. During both years, large influxes of narwhals entered the study area during August with different age classes entering in 2014 than 2015. Such large interchanges between summering areas have not previously been documented and likely influenced the proportion of calves among narwhals present.

Time series analyses of genetic changes in Mediterranean striped dolphin (Stenella coeruleoalba), in response to well known Morbillivirus epizootics over a 21 year period

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Morbillivirus infection is a common pathogenic challenge in cetaceans, which has caused well described epizootics in several species across the world. The Mediterranean striped dolphin is a notable example, with two well described epizootics in the past 30 years. Although several studies have been made on the Morbillivirus strain, comparatively few have analysed the genetic composition of the host. Here we provide the first nearly complete time series assessment of genetic changes in striped dolphin from 1988 to 2008 (covering the two best described Morbillivirus epizootics), for both 15 microsatellite loci and functional immune system genes (SLAMF1, Nectin4, TLR4,DQB2). Our temporal analyses show significant cyclical fluctuations in genetic composition, which correlate in time with the occurrence of morbillivirus epizootics. Evidence of selection can be found in both microsatellite markers and both SLAMF1 and DQB2. For SLAMF1 in particular, the frequency of a non-synonymous SNP known to confer resistance to the virus in other species is seen to increase during peak epizootics. The genetic changes of immune system genes are consistent with different host-pathogen models depending on their function, suggesting survival likely results from a combination of the host genetic variation and the occurrence of opportunistic infections. These results suggest that Morbillivirus survival likely involves a genetic component, and that the Mediterranean striped dolphin population is likely undergoing adaptive changes to the repeated epizootics. Our genetic analyses allows us to establish a more accurate cycle time for Morbillivirus occurrence, which can help predict future occurrences more precisely. In addition, the comparison of genetic data with monitoring data

from the Ligurian Sea, shows that the repeated epizootics have likely cause lasting changes in the population age structure. Overall, our study shows the benefits of time series analyses of host genetic composition, in understanding the effects of pathogenic challenge in wild cetaceans.

Foraging habitat influences pup size in southern elephant seals

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Maternal foraging success is an important determinant of offspring size and survival in many pinniped species. Environmental factors such as sea-ice extent and climate are known to influence this in southern elephant seals, but broad-scale habitat preferences of mothers (i.e. Antarctic vs sub-Antarctic foraging areas) have also been influential in some populations. We used stable isotope values in the whiskers of newly weaned southern elephant seal pups in Peninsula Valdes (Argentina) collected over two years (2011 (n=60) and 2012(n=68)) to quantify the influence of habitat on the size of pups produced by mothers. We identified four patterns of maternal habitat use: (i) predominant use of the Patagonia Shelf (7% of individuals), (ii) focused oceanic foraging (55%), (iii) exploratory oceanic foraging (16%) and (iv) intermediate oceanic foraging (23%). Pups of mothers that foraged on the Patagonian shelf were longer (mean=143.6±7.5(s.d.) cm) than the oceanic groups, and pups of mothers with focused oceanic foraging were longer (137.6±9.6 cm) than the other two oceanic groups (132.5±11.1 and 135.5±9.5 cm respectively). The patterns of habitat use also varied among the two years, with more mothers using the Patagonian Shelf in 2012 than 2012 (10% vs 3%). In 2012 more mothers exhibited the exploratory oceanic foraging strategy (53%) than in 2011 (46%), resulting in the pups being overall significantly smaller in 2012. We contrasted phytoplankton abundance (from satellite ocean colour) from within the core winter foraging areas identified in previous satellite tracking studies and demonstrated that there was lower phytoplankton in the Patagonian shelf (PS) between the study years, but the values were similar in the oceanic foraging areas. Thus, although the PS is highly productive and consistent physical environment foraging conditions on the shelf may have been poorer in 2012 than in 2011 as reflected by pup size and SI composition.

Identification of behavioural states of grey seal pups in the southern North Sea

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Grey seals (*Halichoerus grypus)* have become an important part of the ecosystem in the southern North Sea over the last 50 years. The largest colony in German waters is located on Helgoland, a small island 48 km from the German coastline in the south-eastern North Sea. Information on behaviour of juvenile grey seals after weaning is scarce. However, this period is a crucial phase of their life cycle, when pups need to develop successful foraging strategies to cover the high-energy demands of survival and growth. Knowledge on behaviour and changes within, with the pups' age, is essential to understand processes influencing the population and its adaptability. We therefore recorded the movements of 11 juvenile grey seals born at Helgoland between 2015 and 2017.

For identification of behavioural states, we applied the Expectation-Maximization binary Clustering (EMbC), a robust non-supervised multi-variate clustering algorithm. It allocates the different behavioural states based on speed and turning angle and assigns each location to one of four clusters. Fast directional movement was interpreted as "fast travelling" behaviour, the two states with high turning angles were merged into one and interpreted as "foraging" and slow directional movement was interpreted as "slow travelling/resting" behaviour. A mean of 43 % of the individuals' locations were classified as slow travelling/resting, 52 % as foraging and 5 % as fast travelling. As pups undergo behavioural development through time, information collected from adult behaviour such as values for speed and turning angle, cannot easily be transferred to identify behavioural states of pups. The EMbC analysis does not base on prior information and thus provides an objective approach to classify the pups' behavioural states, contributing to our knowledge of grey seal pup behaviour.

Facial nerve homologies in cetartiodactya

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In the human face, the facial nerve (N. VII) is divided in five rami, each for a defined horizontal level. In the terrestrial cetartyiodactyls, such as the bovine, the motor branches of the face are divided in two Rami buccales, a dorsal branch and a ventral branch. Here, in general, the ventral buccal branch innervates muscles associated the lower jaw while the dorsal branch extends to the nasal region. In the toothed whales dissected macroscopically for this study (porpoise *Phocoena phocoena* and dolphins such as *Grampus griseus* and *Stenella attenuata*) we found only a strong dorsal branch reaching the facial muscles of the nasal complex but no ventral branch. Thus we hypothesize that the well-developed dorsal branch in toothed whales is homologous to the Ramus buccalis dorsalis of terrestrial Cetartyodactyls while the Ramus buccalis ventralis is missing.

Source parameters estimates of free-ranging Irrawaddy dolphins (Orcaella brevirostris) echolocation clicks while foraging in Brunei Bay, Malaysia.

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Free-ranging Irrawaddy dolphin clicks were recorded using a towed two-channel hydrophones system in shallow habitat of Brunei Bay. Recordings were made during foraging. Mean apparent source level peak-peak (ASL_{pp}) of clicks was 201.23 dB (SD=7.31) re 1 µPa at 1 m. Mean ASL_{rms} was 190.58 dB (SD= 7.53). Mean peak frequency and centroid frequency were 116.51 kHz (SD=15.19) and 116.17 kHz (SD=14.47) respectively. The clicks were with mean duration of 21.14 µs (SD=7.16), -3dB bandwidths of 51.83 kHz (SD=17.66), -10dB bandwidth of 100.97 kHz (SD=20.29), and RMS bandwidths of 26.79 kHz (SD=4.87). The clicks of Irrawaddy dolphins have a mean inter-click-interval of 46.39 ms (SD=32.05). High repetition rate and low source level of clicks produced by the Irrawaddy dolphins in Bay of Brunei possible adaption towards shallow foraging ground and short range detection.

Are killer whales attracted to Norwegian herring fishing vessels?

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Marine mammals often interact directly with fishing operations because they may target the same species. Interactions with fisheries may benefit foraging opportunities, but also increase the risk of entanglement, collision and resource competition. In recent years, vast winter aggregations of herring have attracted large numbers of killer whales, humpback whales and herring fishing vessels to local fjord systems in northern Norway. Consequently, whales and fishing vessels often co-occur in restricted areas, especially in situations where whales appear to be directly attracted to herring fishing operations to exploit fish that are aggregated by the fishery or discarded fish. This attraction is most apparent in killer whales. To study the interactions between killer whales and fisheries, we equipped 14 killer whales with Argos satellite tags, between November 2017 and early February 2018. We explored A) the extent of the spatial and temporal overlap between fisheries and killer whales, B) the direction of the interaction, i.e. are killer whales attracted to the fishing operations, or vice versa, and C) the influence of fishing activity on the movement direction of killer whales. We found substantial overlap between killer whale habitat use and fishing activities, in particular within the fjords. The interaction between whales and fisheries appears to be directed towards the fisheries, as killer whales often responded to the start of a fishing event by approaching the location of the fishery. In some cases, such a response was detectable in whales more than 30 km from active fishing operations, suggesting that killer whales respond to acoustic cues. Killer whales also aggregate more densely together in the vicinity of fishing vessels than in the absence of fisheries. Finally, we found that killer whales often selected directions where fishing activity were active, which

indicates that killer whales actively seek out active fishing vessels.

Atlantic spotted dolphin (Stenella frontalis) and bottlenose dolphin (Tursiops truncatus) nearshore habitat utilization, Bimini, the Bahamas.

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Bimini, The Bahamas include two islands surrounded by a diverse assemblage of ecosystems and a large array of organisms, including two delphinid species, Atlantic spotted dolphins (*Stenella frontalis*) and common bottlenose dolphins (*Tursiops truncatus*, inshore ecotype). Distribution and sighting data of both delphinid species have been collected since 2003 (Dolphin Communication Project). Baseline group composition by species and nearshore habitat utilization exist (Melillo-Sweeting et al. 2015), but an investigation by age class or sex does not. Since this initial study, several potentially influential events have occurred, including Atlantic spotted dolphin immigration, hurricanes, continued and varied tourism and boating, pier construction (dredging, pile driving) and new-use phase of the commercial pier. This study examines Atlantic spotted and bottlenose dolphins' use of coastal areas immediately offshore of Bimini, with attention to potential age class and sex variation for years 2003-2018. Studies on resident dolphin populations from around the world have shown significant differences in distribution by sex (Michaud, 2005; Ruckstuhl & Neuhaus, 2005; Rossman et al., 2015; Sprogis et al., 2018), with change in seasons (Ridgway & Harrison, 1998; Wells & Scott, 1998), by predation and prey availability (Heithaus, 2001; Heithaus & Dill, 2002), and by habitat preference, as well as differences with age (Toth et al., 2011). Preliminary analyses from 2014-2016 show a significant difference in location by species ($p<0.001$) and by year ($p=0.014$). Significant differences between species and years also exist in male ($p=0.046$) and female ($p<0.001$) abundances. A comprehensive analysis of age class and sex differences for both delphinid species will help identify group composition and behavior at this location, as well as how these factors might impact possible responses to changes in the habitat.

Signal degradation as a potential cue for judging sonar distance: Discrimination of acoustic stimuli with high-frequency attenuation and reverberation in bottlenose dolphins.

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Some reports have noted a dependence of behavioral reactions on the distances between cetaceans and naval sonars. Specifically, sources perceived by a listener as being nearby can elicit a more immediate or stronger response. Unfortunately, little is known about the specific acoustic features that marine mammals might use to determine the range to a sound source. This study examined the potential for bottlenose dolphins to attend to range-dependent acoustic features when classifying frequency-modulated tones with harmonic structures similar to those of some naval sonars. Various degrees of high-frequency attenuation (HFA) and reverberation (REV) — both of which occur as sounds are transmitted over long distances under water — were simulated in the stimuli. Dolphins were trained to produce phonic responses upon hearing tones simulating a "long-range" source (30 km), and to withhold responses for tones simulating "close-range" sources (up to 1 km). Probe stimuli with simulated ranges that were intermediate to these standard tones were included once the long-vs.-close discrimination behavior was reliably performed. Responses to these probes were used to infer the manner in which the dolphins classified intermediate-range stimuli based on HFA and REV. The dolphins responded to nearly all probes with HFA and REV corresponding to 10 and 20 km. Responses to probes with 1 or 2 km of signal degradation were less common. Additional testing in which HFA and REV were decoupled from the simulated source range and manipulated independently suggested that the dolphins primarily used HFA as opposed to REV in making response decisions for probes. These results suggest that the HFA and REV aspects of signal degradation that occur as sonars spread over long distances under water can potentially be used by cetaceans when deciding appropriate behavioral reactions. [Funded by U.S. Navy Fleet Forces Command].

Infrared thermal imaging of sperm whales (Physeter macrocephalus) off the western North Atlantic outer continental shelf.

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Deep diving cetaceans must maintain a high, relatively constant body temperature as they thermally "migrate" between warm surface and cold deep waters multiple times per day. Although they possess anatomical and physiological adaptations to conserve heat, there exist few direct measures of the thermal biology of these mammals. Using infrared (IR) thermography, we investigated the thermal biology of sperm whales (*Physeter macrocephalus*) encountered during research cruises off the western North Atlantic outer continental shelf in winter and spring 2019 (NOAA Permits 14809-03 and 16473). Sperm whales foraging in this region experience a range of ambient temperatures as they travel between warm, Gulf Stream surface waters (mean 22.8 ºC in this study) to cooler, abyssal waters below. IR images (FLIR P50) were collected when weather and sea state permitted and analyzed using FLIR ThermaCam Researcher 2001. Dorsal fin, dorsolateral body, head and fluke surface temperatures were measured and compared to independently collected water temperatures for each sighting. Preliminary analyses of thermal images demonstrate that the dorsal fin and flukes were on average 0.2–1ºC warmer than surface water temperatures, while the head and dorsolateral body surfaces were 1.00–1.5ºC cooler. A single individual, tracked over a 10 min period at the surface, displayed warming of the dorsal fin and dosolateral body from temperatures 0.5 – 1.0ºC cooler, to temperatures 0.5 – 1.0ºC warmer, than water temperature. These preliminary data demonstrate that the sperm whale body surface is thermally dynamic and heterogeneous. Ultimately, our goal is to collect thermal images of D-tagged individuals to investigate how surface temperatures change with dive behavior. These thermal profiles provide baseline data for future studies that may (a) test the efficacy of IR as a mitigation tool for, and (b) directly measure the response of deep divers to, anthropogenic stressors such as seismic surveys.

3D Reconstruction of marine mammals from 360° photographs.

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3D renderings of marine mammal body forms benefit research in fluid dynamics and also provide engaging interactive tools for outreach activities. Current models rely largely on idealized dimensions and artistic renderings. Our aim was to develop a low-cost method of generating 3D models of individual animals in both a stranding setting and captive research environment. We explored a photogrammetric method that utilizes a 360º series of photos around the animal to stitch together a 3D reconstruction of the body. Photo collection requires only a single camera and low-cost anchoring targets to be available on site. Advanced processing tools are required only in the analysis phase, allowing researchers and stranding teams to bank photo data for later processing. The procedure was tested during two North Atlantic right whale (*Eubalaena glacialis*) and one humpback whale (*Megaptera novaeangliae)* strandings. 3D models were successfully created for the carcasses, including details of injuries and entanglement. Practical application of this method in the field demonstrated potential for collecting morphology data on largely inaccessible animals, one of which is a critically endangered species. This field testing allowed specific challenges to be identified, such as effect of background image complexity and motion, unique reflectivity issues with whale skin, and image scaling demands and limitations. Those challenges were addressed in follow-up research with small resident marine mammals in an aquarium setting. We also explored the use of these models as outreach tools. Portions of the body forms were 3D printed to provide hands-on teaching materials. To provide a digital interactive experience, we imported the models into a virtual reality environment (Unity software with an Oculus Rift headset), allowing users to view and manipulate the digitized specimens in a 3D setting.

Predicting spinner dolphin (Stenella longirostris) habitats in Lovina (Bali, Indonesia): Implications for the management of

dolphin watching tourism.
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Boatmen in the Lovina Marine Protected Area(Bali, Indonesia) have been taking tourists to see spinner dolphins offshore from their villages since 1987. Generating more than USD 4 millions of attributable expenditures (2008 and 2013 data), this industry has attracted many participants (e.g. 182 independent tour boats in 2010). Surveys of western tourists, the most important customers, indicated high levels of dissatisfaction with boat crowding and inconsiderate boat driving behaviours. Suggested reforms include improved codes of practice and reduction in the number of boats. We explored the potential for alternative reforms by investigating the spatial distribution patterns of spinner dolphins in Lovina across different seasons (wet and dry). We analysed spinner dolphin sightings using data from 30 scan samplings days (2008, 2009) and 12 point survey days (2009, 2010) over 100 km^2 using Maximum Entropy modelling to identify dolphin habitat suitability based on 56 independent sightings and 6 environmental variables. Irrespective of the sampling methods, the spinner dolphins were consistently sighted close to the 100m isobath (4 models with AUCs $\geq$0.783), as in Hawaii. The 100 m isobath is 3-4 km offshore and the wet season models suggest that it is associated with areas of higher primary productivity.Our analysis indicates that the location of dolphin sightings in Lovina is predictable and that the suitable habitats extend beyond the usual tourism interaction areas and outside the MPA boundaries. This result suggests that the boundaries of the MPA should be extended to include additional dolphin habitat and that the spatial management of tour activities should be considered as an additional conservation tool to reduce boat crowding.

Cetacean conservation through citizen science in Kenya
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Prior to the formation of the Kenya Marine Mammal Network (KMMN) there was scant information about cetaceans in Kenya waters, species and distribution, resident populations and migration routes for conservation planning purposes. Furthermore, little was known about the effect of increasing anthropogenic threats on cetaceans as a result of human population growth along the Kenyan coast and resulting coastal developments.

In order to provide a cost-effective means of carrying out broad scale, long-term monitoring of cetaceans along the Kenya coast a coalition of researchers, conservation groups and government agencies established the KMMN in 2011 as a citizen science data gathering platform. The report area covers the whole 536km of the Kenya coastline and both inshore and offshore waters. From 2011-2018 data was received through designated boat surveys, opportunistic reports from marine users, and Marine Mammal Observers (MMO) from seismic survey vessels. Data collection was assisted by advancements in communication technologies and mobile phone applications including social media and WhatsApp.

The KMMN has recorded 24 species and received a total number of 1,250 of sightings from 112 reporters during the study period. Reports also included 3 entanglements and 21 dead strandings, with 2 necropsies performed.

Information received has been disseminated to the tourism sector to help increase awareness and has contributed to a growing dolphin and whale watching industry, providing economic benefits to impoverished coastal communities.

This study highlights the value of citizen science programs and it demonstrates the effectiveness in carrying out long term monitoring of cetacean species, providing a cost-effective effort in gathering data on cetaceans and monitoring threats and welfare. In the future, KMMN will enable the setup of a rapid response stranding network and ongoing data collection will assist management authorities in developing a national cetacean conservation strategy and marine spatial planning.

Predicting cumulative impacts of disturbances on marine populations.
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Marine ecosystems are exposed to a wide range of disturbances that cause animals to change behavior and forage less efficiently, as well as disturbances that directly influence animal survival. Here we present a process-based modeling framework for assessing the cumulative population consequences of such disturbances. It enables population effects to emerge from the reduced energetic status and fitness that individual animals experience when having to flee from disturbances, combined with direct mortality associated with some types of disturbances. Due to the generality of these processes, the framework is applicable to a wide range of species, but here we demonstrate its use by assessing the impact of wind farm construction noise and ship noise on the North Sea harbor porpoise population.

The study shows how the exact timing and spatial distribution of disturbances can affect the dynamics of marine populations and how their cumulative impacts can be assessed with process-based models that directly incorporate animal movement, energetics and fitness. They introduce a new level of realism in marine spatial planning, which will be crucial for ensuring the long-term survival of sensitive marine populations. Process-basedmodels that build directly on the mechanisms that determine animal fitness are expected to have high predictive power in novel environments, and we discuss how they can be used to assess the combined impacts of different kinds of anthropogenic disturbances, includingnoise from offshore work, climate changeand mortality related to by-catch in commercial fisheries.

Behavioural responses of harbour seals to vessel noise in the North Sea

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Due to intense global ship traffic, vessel noise is one of the most dominant noise sources in the oceans. Vessel noise is known to impact marine species, such as cetaceans - from masking of communication to behavioural changes, e.g. disrupting foraging activities. However, effects of vessel noise on free-ranging pinnipeds are much less studied. Hence, the aim of the present study was to test for behavioural responses of wild harbour seals (*Phoca vitulina*) to vessel noise in the highly trafficked North Sea. In this context, 10 harbour seals were instrumented with long-term sound and movement tags (DTAG-4), in the Wadden Sea. These tags consist of a triaxial accelerometer and magnetometer, pressure sensor, snapshot GPS and hydrophone (48 kHz sampling rate) and are able to record continuously for four weeks. DTAG sound recordings were screened for passing vessels. As vessel noise is partially masked by low-frequency flow noise from acceleration of the seal, we chose an octave band (1 kHz), whose energy is largely unaffected by the animals' activity and could hence be used to identify vessel passes. To avoid sound transients from splashing, bubbles, etc. at the surface, only sound recorded below 1 m water depth was analysed. Tests of behavioral reactions focused on immediate changes in dive and activity parameters (e.g. descent/ascent rate, dive depth, dive frequency, heading, jerk) prior to, and after, ship encounters, centered on the time of maximum received third octave band levels. Data analysis indicate immediate responses to high-level vessel noise, e.g. avoiding the surface and diving to the seafloor. In addition to immediate responses to vessels, behavioural patterns also changed, e.g. from foraging to travelling, compared to random subsets of the data. These findings are relevant for the development of noise limits for achieving "good environmental status" defined by EU's Marine Strategy Framework Directive.

Ecological implication of marine mammal foraging in deep depth in relation to global

warming: A case study of northern elephant seal.

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Northern elephant seals dive continuously into the mesopelagic zone in the Northeast Pacific, shallow at night (400-600m, shallow mesopelagic zone) and deep during the day (500-1000m, deep mesopelagic zone). We investigated foraging behavior using jaw motion recorders (kami kami recorders) and video recorders to measure the efficiency of feeding at these extreme depths. Our studies indicated more than 40% of their feeding events occurred in the deep mesopelagic zone, which overlaps with the oxygen minimum zone (OMZ). We predicted that prey, mostly fish, in this low-oxygen environment were metabolically limited and, therefore, easier to capture. We examined this prediction using video recorders and found (1) many fish were drifting motionless in the water column until the seals were very close, (2) seals did not use a quick attack motion for the large benthic fish but instead chased them slowly until the fish were exhausted into a motionless condition due to low oxygen content, (3) this slow attack feeding mode (silent attack) may enhance foraging efficiency when feeding on large prey, which would be more difficult in an oxygen-rich environment. Furthermore, we predict that seals, which attempt to optimize foraging efficiency, may consume a large amount of prey and energy from this zone – perhaps more than the day-time feeding in the shallow mesopelagic. The advantages of foraging in the OMZ may also occur in the deep-diving whales.

Recent global warming affects the deep ocean environment around the world, including the Northeast Pacific, by shoaling the OMZ. This could be beneficial to deep-diving species by further increasing foraging efficiency at a population scale.

Investigation of the social preferences of bottlenose dolphins using a dolphin acoustic touch panel

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The ability to discriminate between group members is important for social animals. Much is known about social cognition by vocalizations through auditory playback experiments. However, visual information may also be important for individual cognition. Bottlenose dolphins (*Tursiops truncatus*) are known to produce individually distinctive signature whistles that broadcast the identity of the caller. Conversely, in dolphins, external forms such as body color and body shape differ depending on the species and individual; thus, the possibility of visual species and individual cognition may be considered. In this study, we examined the social preferences of bottlenose dolphins using a Dolphin Acoustic Touch Panel (DATP; AquaSound Inc.). This device can visualize dolphin echolocation clicks as well as function as an acoustically operated touch screen. We presented dolphins with two different stimuli on the screen and recorded the number of time they selected each stimulus. As stimuli, whole body photographs of conspecifics and other species of dolphins were used. When a dolphin selected (touched by clicks) a stimulus (still image) on the screen, a video of the individual associated with the stimulus was played back. Dolphins preferred to view the video images of themselves, familiar individuals (conspecifics or other species), or conspecifics. Dolphins also showed a specific response to the video images of familiar individuals. These results indicate that bottlenose dolphins can discriminate individuals in video images and show social preferences.

Sexual dimorphism observed in the laryngeal sac of common minke whale: Functioning for "song" generation?

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The laryngeal sac is a ventral diverticulum of the respiratory tract of baleen whale, but its function is not defined. We hypothesized that, if this organ play an important role of sound generation, intersexual morphological differences would be observed on it, because several species of male baleen whales, including common minke whale emit a typical sound so called as "song" to appeal to the other individuals in the breeding season. Therefore, we aimed to reveal intersexual difference on the laryngeal sac in the North Pacific common minke whale (*Balaenoptera acutorostrata*). Sixty-one animals (male: *n*=40, female: *n*=21) were sampled through JARPNII and NEWREP-NP. We measured the length of eleven sights and the weight of laryngeal sac. Sexual dimorphism was analyzed by comparing the relative growth equation of each measurement sight to the body length. The relative growth pattern of seven measurement sights showed significant sexual differences. The differences were mainly detected in the depth of the sac and the thickness of the surrounding muscular layer around the sac. Although sexually mature males had different development rate of the muscle of laryngeal sac, this rate showed a positive correlation with the weights of testis. Furthermore, as to sexually mature animals, the male laryngeal sac weighed about 1.5 times heavier than females. The intersexual gap on the weight became conclusive among the animals which were more than 6 m in their body length. This indicates that the male laryngeal sac would rapidly develop for preparation of sexual maturity. Present study clarified that the volume of the laryngeal sac shows clear sexual dimorphism and proposed that the development rate of this organ would be associated with its sexual status. Finally, we concluded that the laryngeal sac of baleen whale plays an important role not only in sound generation but also in "song" generation.

Identifying suitable habitats for harbour porpoise (Phocoena phocoena) conservation in Galician waters, NW Spain.

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Special Areas of Conservation (SACs) are an increasingly used conservation tool to protect the oceans and its biodiversity. The harbour porpoise (*Phocoena phocoena*) is elegit to such protection by Annex II of the EU's Habitats Directive; particularly the Iberian harbour porpoise, a genetically distinct population, is in need of such conservation measures. This study aims to define the Iberian harbour porpoise ecological niche and identify suitable areas for its conservation in Galician waters (NW Spain). Boat-based surveys, recording ecogeographical data and harbour porpoise presence, were carried out throughout August and September 2017 along the north-westers coast of Spain. Data was analysed in the software Biomapper through Ecological Niche Factor Analysis, a presence-only model that predicts habitat suitability across the entire study area, based on the environmental conditions encountered during harbour porpoise sightings. The dataset used in this study, generated a good quality model which defined harbour porpoise ecological niche as narrow, based on a clear specialisation pattern of shallow areas with high salinity and high tidal coefficients. The habitat suitability map highlighted this narrow niche breadth by identifying three regions, only covering 0.15% of the study area, as highly suitable, because harbour porpoises' ecological preferences differed greatly from average conditions across the study area. In future conservation and management plans for the Iberian harbour porpoise, these three areas within and near the Ría of Arousa should be further assessed for their suitability as SACs; in particular evaluating anthropogenic impacts within them.

Protect or forget? Multidisciplinary approach reveals occurrence of small cetaceans in highly anthropogenic-impacted waters: Dubai and Abu Dhabi, United Arab Emirates (UAE).

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In the Arabian/Persian Gulf limited dedicated cetaceans surveys have been conducted and most of them are outdated. Two aerial surveys (1986 and 1999) conducted in Abu Dhabi waters revealed a 71% decrease in small dolphin sightings (*Tursiops aduncus*, *Sousa plumbea* and *Neophocaena phocaenoides*). In the past thirty years, the UAE coastal waters have experienced drastic changes with a five-fold increase in human population, extensive land reclamation, overfishing and increased water pollution.

We utilised a multidisciplinary approach (survey questionnaire, opportunistic sightings, boat-based and land-based surveys) to: a) confirm the species present in the coastal waters, b) identify their distribution range and frequency, c) determine

preferential habitat characteristics, d) provide baseline information for estimating population trends.

Sixty-one questionnaires were administered among boat users, 84% reported seeing dolphins – the majority, in the 2 months prior to the interview. In Dubai coastal waters, 55 boat-based transect surveys were conducted in 2014, covering 3799 km, recording 20 sightings and confirming all three abovementioned species as most frequent. Photo-identification analysis identified 23 humpback dolphin and 89 bottlenose dolphins with a re-sighting rate of 39% and 22% respectively. In Abu Dhabi 109 land-based surveys (tot 406 hours) were conducted and recorded 69 sighting of only humpback dolphins. A total of 1296 occasional sightings reported by the public, validated the same frequent species, with another 4 recorded only occasionally. Ecological niche modeling (using Maxent) for the three most common species confirmed a clear preference for coastal habitats and identified distinct preferred habitat for each species.

We concluded that these three species regularly occur in UAE coastal waters and their habitat greatly overlaps with areas highly affected by anthropogenic activities. Distinct habitat preferences for each species further suggest the need for regular monitoring and species-specific mitigation plans, if current trends of reduced cetacean occurrence are to be reversed.

What the public knows & thinks about whales & dolphins - an international survey.

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In 2015, an online survey was conducted to investigate public attitudes and perceptions toward key cetacean (whale, dolphin, and porpoise) conservation and 'hot topic' issues such as legislative protection, whaling and cetaceans in captivity (n=858). Perceptions of participants on the conservation priority of cetacean species did not match with the factual IUCN status, where most participants assumed that the larger and more charismatic whales (blue whale, 24.01%; humpback whale, 22.14%; and killer whale, 23.43%) were more endangered or more important to conserve than the small cetacean species such as the Vaquita or Hector's dolphin. 39.74% of participants indicated the bottlenose dolphin was the most important to conserve. The majority of participants considered dolphins and whales to be "under protected" or only "slightly protected" (29.95%; 41.96%, respectively) and expressed that marine mammal conservation laws and policies were "very important" or "important" (47.43%; and 37.88%, respectively). In addition, 86.83% of participants expressed opposition to the hunting of dolphins and whales (57.93% "strongly opposed" and 28.90% "opposed"); however, only 47.44% of participants were aware that several countries are still involved in whaling. Respondents were significantly more likely to be opposed to displaying dolphins and whales in marine theme parks and aquariums (opposed to captive display: 54.43%; support captive display: 45.57%). Only 5% of US respondents from the USA strongly supported keeping dolphins and whales in marine theme parks and aquariums. Participants that support cetaceans in captivity were significantly more likely to believe cetacean conservation is not important. Six times as many respondents, or 86%, preferred to view cetaceans in the wild via whale-watching (61% preferring boat-based, 25% land-based) versus in captivity. A lack of awareness of the conservation status of whales and dolphins suggests that greater outreach to the public about the conservation status of whale and dolphin species is needed.

Measuring nares expansion reveals variability in breath area and duration

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Studying baleen whale respiration has historically been limited to surface observations of breath counts, but the degree to which all breaths are equal in length or nares size remains unknown. We used a novel method, integrated area, to quantify the duration and area of nares expansion during inhalation periods to understand the variation

between initial**,** recovery (all breaths in between initial and terminal), and terminal breaths. Video-recording and orientation-sensing tags were deployed posterior to the nares on 18 blue, fin, humpback, grey and minke whales. We measured the integrated nasal area for 800 surface series. In some cases, the videos were paired with UAS photogrammetry to estimate the changing area of the open nares over the duration of inhalations. We compared the integrated nares area against inter breath interval, previous dive depth, and categorical behaviors including foraging and non-foraging. Initial results indicate that the integrated area of nares expansion on terminal dives is 1.67 times greater than initial and recovery breaths. While the nares size during initial and recovery breaths were about equal in area, the recovery breaths differed from each other and continuously increased in nares expansion as the surfacing sequence progressed. We found that nares expansion is more consistent during a surface period after deeper and longer dives, leading to future questions about how mysticetes preplan for dives and behaviors. This new technique of using video data to measure nares expansion could be improved with higher resolution cameras to estimate the flow rates of air during inhalation. Advances in bio-logging technology will increasingly enable researchers to measure physiological parameters that are important for gaining an in-depth understanding of mysticete energetics, foraging performance, response to environmental change and human disturbance.

African manatee (Trichechus senegalensis) threat assessments in Senegal.

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In Senegal, the African manatee exists both along the coasts as well as inland in rivers, lakes and seasonal floodplains. Manatees were previously heavily hunted in Senegal and were believed to be almost extinct, but recent surveys have shown it to be present in all aquatic and marine systems. In 2018-2019, we conducted 167 interview surveys to identify and quantify threats with fishermen and other local people on Senegal's central coast from Mbour to Toubacouta, in 22 villages around Lake Guiers, and along the Senegal, Faleme and Gambia Rivers within Senegal. Questions addressed frequency of manatee sightings, presence of threats and poachers, knowledge of manatees killed, injured or caught, and other sighting information. Threats identified by this study included (in order of significance) accidental capture in fishing nets, mortality in dam structures, entrapment behind dams, illegal poaching, and habitat loss due to human development. Results indicated that fisheries bycatch is frequent in both marine and inland waterways throughout the country, but difficult to quantify due to fishermen's fear of arrest. Two dams along the Senegal River have killed a minimum of 10 manatees since 2009, through capture in gates and entrapment during the dry season. We found only three locations where manatees are still poached in Senegal. Rainy season floodplain habitat loss along the Senegal River was quantified for the first time using Google Earth. We also documented locations of motorized boats, as they are likely an emerging threat for manatees. Results are being provided to the Senegal Water and Forestry and Fisheries Ministries as evidence for them to enforce laws to stop poaching and bycatch mortality. We are also working with the dam authorities to reduce mortality in the Senegal River. Lastly, we are raising awareness through education programs and encouraging reporting through a new hotline.

Blubber fatty acid signature analysis of harbor seals in Alaska over 14 years

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While a predator's blubber fatty acid (FA) profile does not exactly match their prey, it has been shown to reflect the FA profile of consumed prey in many marine taxa. As natural and anthropogenic changes in ocean conditions cause prey populations to migrate further offshore, pinnipeds will likely respond by adjusting their diet. In this study, we examined long-term spatial and temporal trends in the blubber FA composition of Alaskan harbor seals (*Phoca vitulina*) to determine (1) if FA profiles vary spatially and temporally, and (2) could potentially be used as an index to monitor long-term changes in their environment. Blubber samples were collected across 14years (n=760) from Kodiak (KOD, n=158), Prince William Sound (PWS, n=254) and Southeast (SEA, n=348), Alaska. A subset of 16 FAs (comprising 90% of the total) was used in analysis. Relationships among

blubber FA signatures, regions, and seasons were analyzed using random forest. The model classified regions with 93.68% accuracy, identifying C20:1n-11 as the major predictor of region. Within PWS, the model classified season with 81.10% accuracy, with summer having the least misclassifications (3.11%) compared to spring (63.63%) and winter (75%). Within KOD, the model classified season with 95.57% accuracy, with summer having the least misclassifications (1.59%) compared to fall (4.65%) or spring (22.22%). Lastly, within SEA, the model classified season with 75.57% accuracy, with fall having the least misclassifications (12.94%) compared to spring (24.82%) or summer (75.68%). Important seasonal predictors within each region varied, with C16 identified as a major seasonal predictor in PWS, C20:1n-9 in KOD, and C22:1n-9 in SEA. These results suggest that blubber FAs do exhibit regional and seasonal variation. When individual FAs were graphed seasonally over time, individual FA concentrations did change, suggesting that certain FA signatures could potentially be used as an index to monitor environmental changes.

The effect of anthropogenic disturbance in a changing environment on the lifetime reproductive success of eastern North Pacific blue whales (Balaenoptera musculus).

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Animals make behavioural and reproductive decisions in the context of a variable environment that require trade-offs between survival and lifetime reproductive success. This can be formalized by modelling individuals' energy levels, which can help quantify population-level consequences of anthropogenic and environmental stressors. We developed a dynamic state variable model for the spatially explicit behaviour, physiology and reproduction of female eastern North Pacific (ENP) blue whales (*Balaenoptera musculus*). Our aim was to investigate the spatio-temporal patterns of behaviour that would maximise individuals' overall reproductive output, and to predict the effects of changing environmental conditions and increasing human disturbance on reproductive success. The baseline scenario resembled ENP blue whales' observed energy dynamics, movement patterns and reproductive strategies; over a year, lactating females had a 9% additional net loss in blubber mass compared to non-lactating females, individuals' migratory path tracked prey resources' seasonal variation, and the mean inter-birth interval was 2.42 yr, with a mean of 6.34 yr between the production of calves surviving to age one. Disturbance scenarios suggested that environmental changes could have severe consequences on reproductive success; inter-birth interval decreased to 2.26 yr due to calf abandonment, but the mean interval between the production of calves surviving to age one increased to 12.1 yr. In contrast, whales appeared to compensate for substantial levels of anthropogenic disturbance. Only year-round disturbance, or one in the summer feeding grounds, resulted in an effect size of similar magnitude to that of environmental disturbance. However, the combination of anthropogenic and environmental disturbances that individually had no impact led to small changes in female survival and small to moderate changes in reproductive success, suggesting a synergistic relationship. Across all scenarios, larger body size buffered against disturbance. Moreover, our results implied that females prioritise their survival over their current reproductive attempt, presumably because of their long lifespan.

Cetacean habitat use in the Central North Atlantic: A comparison between baleen whales and deep-diving odontocetes.

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The central North Atlantic Ocean is an important feeding ground for many species of cetaceans. Six of the most commonly encountered species in this region are the balaenopterid fin, humpback, and common minke whale and the deep-diving odontocete sperm, northern bottlenose, and long-

finned pilot whale. The general distribution and abundance of these species have been documented throughout the central North Atlantic; however, little is known about the environmental features that drive their patterns of distribution. Improving understanding of this is important in the context of changes taking place in the North Atlantic as a result of climate change. Using data collected during the North Atlantic Sighting Survey 2015 and environmental covariate data for this region, habitat-use models were developed for each of the six study species, including the first of its kind for the northern bottlenose whale outside the Scotian Shelf. The baleen whales were primarily associated with dynamic variables including three-month-lagged chlorophyll concentrations, sea surface temperature, and absolute dynamic topography. The deep-diving odontocetes were associated with both dynamic and static variables, including sea surface temperature, three-month-lagged chlorophyll concentration, slope, depth, and distance to the shelf edge. The predicted high-use areas for all three baleen whales overlapped while those for the deep-divers were spatially separated. These high-use areas generally differed between the two groups, however all six species were predicted to use the waters west of Britain and Ireland. These results provide additional insights into the environmental features that influence the distribution of cetaceans in the central North Atlantic and provide valuable baseline information for studying the effects of ongoing climate change.

An interactive open-source acoustic analysis tool in R.

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With the rapid development of technology, it is now possible to collect vast amounts of acoustic data both with stationary acoustic recorders and animal-borne archival tags. There is hence an increasing demand for automatic software to support scientists to understand the ocean life better. Currently there are many available tools, but many of them are written in MATLAB (which is proprietary and expensive), close or hard-to-modify source code. Our aim is to provide an alternative free and open-source solution, by developing an **interactive graphical application in R** (which can run on any operating system supporting R and Rstudio, like Windows, Mac and Linux). This can easily be extended by the user with other R-based features. This application supports basic features like current available tools, e.g. make/save/load long-term spectrograms with the ability to *process many files in parallel* (especially useful in desktop computers with many cores and a lot of memory); pre-processing by using well-known filters (Hamming, Hanning, Blackman-Harris, etc.); read/write compressed sound files such as lossless *FLAC files* directly from memory without installing any third-party tool, which saves 50-70% storage (compared to the usual WAV files) and one can embed meta-data (like date/time in headers without having to specify them in the file name). Apart from the classical Fourier spectrogram, the application supports Hilbert spectrogram and click/buzz detection using *Hilbert-Huang transform* which has been shown to perform better in low signal-to-noise ratio data compared with Fourier methods. The application can also import time-depth recorder (TDR) data as well as GPS positions allowing visualization of the detections in different datasets. Features like wavelet transforms and more complex acoustic feature recognition will be included in the future. It is user-friendly and does not require any programming skill to use, and more experienced users can adapt the open-source code for custom use.

A take on years of wrangling over a controversial taxonomy: Delphinus spp. in South African waters.

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The taxonomy of common dolphins (*Delphinus* spp.) remains contentious despite much attention over the past few decades. Various techniques, such as the analysis of cranial and external morphology, postcranial material and different molecular markers, have been used to address this issue. These analyses have generated conflicting phylogenetic reconstructions, leaving taxonomic uncertainties. The situation in South African waters

is no different. We assessed the taxonomy of common dolphins on the South Africa coast using an integrative approach, combining analysis of molecular biology with cranial and external morphology. Analyses included the type specimen of *D. capensis* (BM 41.1734). Sequences were obtained from teeth in the 5' segment of the D-loop region with 458 bp. To add a global perspective, additional sequences were included from GenBank. For the morphology component, crania were photographed in both dorsal and ventral aspects, and geometric morphometric analyses conducted. Molecular and cranial analyses were performed on the same individuals. In addition, 17 external measurements from 45 individuals were analysed. Molecular phylogenetic results suggest that South African specimens belong to a single, highly variable species. The maximum likelihood phylogenetic tree showed some degree of clustering of the specimens. There were no significant differences in terms of cranial size or shape among three clusters identified by hierarchical cluster analysis of morphometric data, in both aspects. Furthermore, the results of the molecular, cranial and external morphology analyses did not show coherence, indicating that morphological variation in the sample is not a function phylogenetic affiliation. Thus, the three lines of investigation supported the presence of a single species of common dolphins in the region. This result is especially important given that South Africa is the type locality of *D. capensis*, demonstrating that further research into the relationships of these dolphins with other groups of *Delphinus* is warranted.

Humpback whale foraging in the Antarctic Summer

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Humpback whales (*Megaptera novaeangliae)* arriving along the Western Antarctic Peninsula (WAP) after migrating from tropical breeding grounds are in relatively poor body condition, having fasted for several months, and must replenish energy stores rapidly. Previous work indicates that humpbacks optimize energy gain in part by increasing feeding lunges per dive as prey density increases with depth. In austral fall, whales track the vertical movement of krill and forage only at night when krill move into the upper water column, requiring less energy/time to search for and consume prey. Little information exists regarding humpback foraging behavior in early summer when light availability is consistent, and krill are more common in surface waters. We deployed high-resolution motion-sensor tags on humpbacks to test the hypothesis that during periods with extended daylight, foraging will be more consistent throughout the day and whales will increase feeding rates when diving deeper, commensurate with increases in krill density. From 2016-19, 16 tags were deployed near Anvers Island. Three-dimensional dive profiles were created and motion-sensor information was used to quantify feeding rates on a per dive basis. In 2018 (n= 6 deployments and 4,120 dives), foraging occurred during all hours of the day, however deeper dives were concurrent with hours of highest solar irradiance: 90% of dives >20 meters occurred between 0700-1900. Preliminary analyses indicate that whales feed primarily at shallow depths with only 90% of all dives being <20 m, consistent with the foraging depths of other sympatric krill predators (e.g. penguins). Our results fill a critical data gap in our knowledge of how humpback whales feed and maximize energy gain early in the feeding season and can be combined with data on body condition and demography to better understand recovery from past exploitation in a rapidly changing environment and the potential for competition among krill predators.

Thirty years of records highlight an Australian stranding hotspot for a resident community of Indo-Pacific bottlenose dolphins within a microtidal estuary

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The cause of dolphin strandings is typically linked to poor health, anthropogenic impacts, navigational errors or misadventure while pursuing prey. We report on bottlenose dolphin (*Tursiops aduncus*) live stranding events in the microtidal (range < 2m) Peel-Harvey Estuary, Western Australia. The estuary is occupied by a year-round resident community of approximately 80 dolphins. Stranding information was obtained from multiple databases as well as recorded during a capture-recapture population assessment study between 2016 and 2019. Live strandings were categorized either as 'high and dry' strandings (HDS) where an individual was no longer submerged, or 'confinement' strandings (CFS) where an individual was trapped by receding tide but was still able to swim freely. Since 1985, a total of 84 stranding events involving 120 individuals were recorded, with over half of these events (n=49) identified as live strandings. All but one of the 17 live strandings (9 HDS and 8 CFS) recorded during the population study involved members of the resident community. Twenty-nine out of 105 residents have stranded at least once, some on multiple occasions. Fourteen of these showed sunburn injury indicative of HDS. All but one adult female successfully reproduced post-stranding. Although seven individuals were confirmed deceased during a live stranding or subsequently due to extensive sunburn, those who survived thrive up to 29 years post-stranding. We conclude that the live stranding events generally involve healthy resident individuals. Both HDS and CFS appear to result from individuals navigating to an area and being caught out by tide rather than individuals getting stranded during a behavioural event such as a prey chase. This study highlights the Peel-Harvey as a live stranding hotspot in Australia. Early detection, monitoring for CFS and quick rescue response for HDS are primary management goals to ensure the welfare and survival of live stranded individuals.

Spatio-temporal patterns in harbour porpoise density: Implications for conservation in UK seas.

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Fisheries-induced mortality poses a threat to the conservation of small cetaceans, particularly opportunistic predators whose ranges throughout productive shelf-seas expose them to commercial activities. Harbour porpoises Phocoena phocoena are ubiquitous in UK coastal waters, but despite their prevalence, estimated levels of bycatch have given reason for concern. A deeper understanding of how distributions vary in space and time is required to assess impacts. While wide-scale distance sampling surveys are financially and temporally constrained, citizen science programs which collect standardized data aboard platforms of opportunity can help uncover density patterns to identify areas of importance. Data collected on ferries from 2006-2017 were analyzed to estimate harbour porpoise densities along routes southwest of Cornwall, the English Channel, and the North Sea. Region-specific detection functions were calculated to account for the number of individuals missed along transects and provide more accurate estimates of relative abundance. Generalized additive models (GAMs) were used to elucidate relationships between distributions and ecological covariates. The highest densities were found in the southwest (0.070 porpoises/km2), followed by routes in the North Sea (0.044 porpoises/km2), and English Channel (0.006 porpoises/km2). Average density in the North Sea appear to have increased by ~30% (95% CI ±0.015 porpoises/km2) over the study, and distributions shifted into the English Channel, suggesting new areas of relative importance. Space-use was region specific, but selected models reflect strong relationships with coastal waters, sea surface temperature, chlorophyll-a, and water column dynamics. Contrasting preferences for highly stratified waters in the North Sea and well-mixed areas in the English Channel suggest distinct foraging behavior. Hotspots in the southwest and northeast UK identify areas for mitigation efforts, especially in Cornish waters where porpoises are highly vulnerable to bycatch. The findings highlight how citizen scientists, together with robust density estimation, can contribute to the conservation management of a common, although threatened species.

A chronic problem: A 20 year summary of confirmed pinniped entanglement cases on Cape Cod, Massachusetts, USA.

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Entanglements and their associated injuries are one of the leading anthropogenic causes of stranding and death for pinnipeds on Cape Cod and southeastern Massachusetts. Over the past 20 years (1999-2018), 156 confirmed cases of entangled pinnipeds have been responded to in this region. Of the 111 cases that had gear present, the majority (n=80) involved neck entanglement in monofilament netting. This type of entanglement is consistent with active gillnet fisheries due to entanglement configuration, prevalence of year-round fisheries and lack of gear fouling. Other entangling material included fishing weirs (n=4), trap/pot gear (n=7), trawl netting (n=2), other fisheries gear (n=5), marine debris (n=7) and uncategorized (n=4). The majority of these cases were gray seals (n=129), but harbor and harp seals were also affected. Out of the 76 live cases, 63% (n=48) were successfully disentangled and either transferred to a rehabilitation facility or treated and immediately released. Due to the extent of the entanglement-related injuries, 5 seals died and 3 were humanely euthanized. More than half the cases were reported dead (n=83), including 43 with gear present. Necropsies were conducted whenever logistics and carcass decomposition permitted (n=47). Significant necropsy findings in cases with chronic circumferential constricting monofilament net entanglements around the neck included severe lacerations, embedded line, sepsis, and poor body condition. Other findings of note included multiple entanglement-induced tracheotomy and large volume pyothorax. The severity of these injuries highlights the serious animal welfare concern that entanglements represent for pinnipeds. Future work should focus on the need to further understand where and how these entanglements occur in an effort to prevent them through mitigation measures.

Project: Towards sustainable coexistence of seals and humans.

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The project "Towards sustainable coexistence of seals and humans, CoExist" (duration 2019-2022) is targeted to take science based actions towards human-seal coexistence in two freshwater lakes situated in Finland and NW Russia. These lakes are inhabited by two ringed seal subspecies (*Pusa hispida saimensis* and *P.h. ladogensis*). The Saimaa ringed seal is endangered (EN) with only ca. 400 seals and the Ladoga ringed seal vulnerable (VU), with population size around 5 000 seals. These seals differ by genetically, morphologically and by their behavior. Nevertheless, they share common challenges from incidental by-catch and climate change aggravated by human activities. In addition, the goals for conservation of these seals are common. This can be achieved by strengthen the Russian-Finnish cross-border cooperation and by enhancing environmental awareness among local residents, visitors, stakeholders and companies. The goals of the project are to produce and share new information on conservation biology on seals by using varied methods (e.g. photo identification and telemetry) and to develop new cost-effective monitoring tools via computer vision together with Finnish and Russian experts. We will use best practices in seal-fisheries conflict mitigation and sustainable seal tourism, and produce recommendations based on gained information. One of the aim is to involve decision-makers taking actions towards sustainable conservation of these endangered seals. University of Eastern Finland coordinates the project that is implemented together with The Finnish Association for Nature Conservation (FIN), Lappeenranta University of Technology (FIN) and Interregional charitable public organization "Biologists for nature conservation" (RUS). The project is granted by South-East Finland –Russia CBC 2014-2020 programme funded by the European Union, the Russian Federation and the Republic of Finland.

Anatomy of the kidneys of Saimaa ringed seal (Pusa hispida saimensis)

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The Saimaa ringed seal is an endangered subspecies that lives only in the fresh water lake Saimaa in Finland. The Saimaa ringed seals have been isolated from the Baltic and Ladoga ringed seal populations for about 9500 years, and during that time they have become genetically very different from other ringed seal subspecies. We studied the kidney anatomy of the Saimaa ringed seal and compared it to the other ringed seal subspecies in an effort to see whether the differences in water salinity are reflected in the kidney anatomy.

We collected samples from 17 Saimaa ringed seals that had been found dead. The kidneys were examined through anatomical dissection, histological stainings and silicone casts. The most notable difference we found was the number of renculi, which was smaller in Saimaa ringed seals when compared to previous studies on ringed seals.

The biggest challenge in our research was the small number of animals due to small population size of Saimaa ringed seals and number of available Baltic ringed seals. Especially in Saimaa ringed seals the age distribution was also emphasized on the sub-adult individuals, and because of the way of obtaining sample material, autolytic changes were often from moderate to severe.

Mutual interactions between Norwegian grey seals and small-scale fisheries.

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Grey seals in Norwegian waters are most abundant from mid-Norway to Finnmark county in the northeast. Population modelling indicated an increase from 3100 animals in the 1980ies to 8740 (95% CI: 7320–10170) grey seals in 2011 (Øigård et al. 2012). Pup counts in 2014-2018 showed a significant reduction in pup production in the most abundant grey seal area from Trøndelag to Lofoten in mid-Norway. In other less abundant grey seal areas, pup production was stable. We estimated the grey seal population to be 3850 (95% CI: 3504-4196) animals in 2018. The reduction in grey seal abundance in mid-Norway is most probably due to increase in by-catches in small-scale gillnet fisheries. Annual by-catch was estimated to be 560 grey seals, mainly in fisheries for monkfish *Lophius piscatorius* and cod *Gadus morhua*, based on data obtained from the Reference Fleet (fishing vessels hired to report on all catches by the Institute of Marine Research).

We used diet sampling and bio-energetic modeling to estimate the grey seal prey consumption along the Norwegian coast. The mean total annual consumption by 3850 grey seals was estimated to be 8084 tons (95% CI: 6166-10191) of various fishes in Norwegian waters; saithe *Pollachius virens* (3059 tons), cod (2598 tons) and wolffish *Anarchchus* spp. (1364 tons) were consumed in highest quantities. Grey seals are assumed to prey on both the coastal component of cod and the migrating Northeast Arctic cod. Norwegian annual fishery catches of coastal cod and Northeast Arctic cod were 35 000-39 000 tons and 192 000-378 000 tons, respectively, in the period 2003-2015. Leisure and tourist catch of coastal cod were estimated to be 13 000 tons in 2015. We conclude that consumption of cod by grey seals is very low compared to fishery catches.

Kinship of mass-stranded populations for Steno and Feresa.

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Delphinid species have various social systems. Killer and pilot whales form stable matrilineal groups. Bottlenose dolphins show a fission-fusion social system with bisexual dispersal. However, kinship among members of a group is unknown in many Delphinid species. Mass-stranding event is one of the opportunities to gain information about their social system. Pygmy killer whales, *Feresa attenuata*, and rough-toothed dolphins, *Steno bredanensis*, are oceanic delphinids distributed in tropical and warmer waters. Here, we investigated the population genetic structure and relatedness (*r*) among individuals of mass-stranded *Feresa* and *Steno* by maternal (mtDNA control region; over 900 bp) and biparental microsatellite DNA analyses (over 10 loci). Samples were mainly from three mass-stranded events in Japan: 12 *Steno* dolphins (male 6, female 6) stranded at Tanegashima Is, Kagoshima in 2017, 6 *Feresa* whales (male 5, female 1) at Fukuoka in 2000 and 7 *Feresa* whales (male 3, female 4) at Miyazaki in 2017. These individuals were estimated to be adult based on body length and genital conditions, with exception of one sub-adult *Feresa* male (BL: 160 cm) from Fukuoka. All female individuals had identical haplotype for the *Steno* population, and males had different types for each individual except for one male. For *Feresa*, the Fukuoka and Miyazaki populations showed different haplotypes, but all members of each population had the same

haplotype. The mean value of relatedness among females are significantly higher than those of males for the *Steno* and Miyazaki *Feresa* populations. Furthermore, some male-female pairs belonging to different matrilineal groups had high *r* values for *Steno*, and the mean *r* value among males in the male-biased Fukuoka *Feresa* population was relatively high. These results suggest that both species have stable matrilineal social systems, and males migrate between matrilineal groups. Additionally, some of *Feresa* males possibly remain in their natal group.

Observations on the orbicularis oculi muscle and the facial nerve distribution of striped dolphin (Stenella coeruleoalba), Dall's porpoise (Phocoenoides dalli) and finless porpoise (Neophocaena phocaenoides).

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To consider homology of facial muscles of dolphins with those of the terrestrial muscles detailed description of the facial nerve is necessary. We dissected four striped dolphins, one Dall's porpoise and two finless porpoises, either stranded or by-caught. In addition to the careful dissection of the facial muscles, the facial nerve branches were traced from the stylomastoid foramen to the antorbital notch. Dissections were made under stereo microscope when necessary.

The dorsal part of the orbicularis oculi muscle (OC) in all the samples contained an aponeurotic (tendinous) area. The forms of that area vary from species to species. Sihler's stain clearly revealed the intramuscular distribution of the facial nerve in the OC. Two branches to the OC, diverged from the facial nerve running parallel to the outer margin of the zygomatic bone, at the anterior tip of squamous bone and the palpebral fissure, distributed almost solely to the ventral part of the OC, with only a few nerve fibers to the dorsal part of the OC.

Although previous studies reported the OC formed a well-developed muscle around the eye, we confirmed the OC did not surround the dorsal part of the eye. This indicates the dorsal part of the OC is weaker and their eyelids may close from below. The difference of aponeurotic areas among species might be caused by the differences of behavior, swimming velocity or the way they use the eyes. Comparison of the mode of innervation of the OC in dolphins we observed and that of the terrestrial mammals in publications revealed that the diverging point of and the route of the branches to the muscle are different. These differences can be explained by the overlapping of the nerve paths in odontocete caused by the specific transformation of head morphology.

Factors affecting bycatch rate of harbour porpoise (Phocoena phocoena) in Swedish waters

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Incidental catch (bycatch) in fisheries is one of the major threats to marine mammal populations worldwide. The harbour porpoise is one of the most common cetaceans in northern Europe. Previous studies have reported high bycatch numbers of harbour porpoises in gillnet fishing operations in the North Sea and Skagerrak Sea. With the aim of disentangling the driving factors behind bycatch of harbour porpoise, we compared bycatch rates of harbour porpoise with data on fishing operations and harbour porpoise distribution. Models were set up involving 8 explanatory variables: net soak time, net string length, net height, net mesh size, net bagginess, water depth, month of operation and porpoise density. From 1995 to 1997, data on gear characteristics and fishing operations of 952 hauls of bottom-set gillnets targeting for cod (*Gadus morhua*), pollack (*Pollachius pollachius*) and hake (*Merluccius merluccius*), operated by 28 randomly selected fishing vessels, were collected by on-board marine biologists in the Swedish Kattegat and Skagerrak Seas. During these hauls, 21 bycatch events were recorded. Data on harbour porpoise distribution was generated from daily positions of 116 individuals equipped with satellite transmitters in Danish waters from 1997 to 2016. Spatial distribution of the tracked porpoises did not show significant temporal variances between the two decades. Generalised linear models with Poisson and binomial distributions were applied to identify the relationships between the porpoise bycatch events and the explanatory variables. The model including the three significant explanatory variables net soak time, net string length and water

depth had the highest explanatory power for the occurrence of bycatch events compared to models involving any other combination of variables. The findings provide guidance for measures to adjust fishing operations and gears to reduce porpoise bycatch rates. The model can be used to predict possible spatio-temporal high risk hot spots to optimise future monitoring efforts.

Singing at Saba: Long-term acoustic monitoring provides new insights on humpback whales habitat use in the Dutch Caribbean.

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We monitored the acoustic activity of humpback whales (Megaptera novaeangliae) in the Yarari Marine Mammal and Shark Sanctuary, located in the Antillean Island chain in the Caribbean.

At the Saba Bank, one Marine Acoustic Recording Unit (MARU) (2011 – 2012) and two Autonomous Multichannel Acoustic Recorders (AMAR) were deployed (2015 – 2019). The analysis of the data was performed in stages: 1. A sub-sample of the data was scrutinized to identify humpback vocalisations from spectrograms 2. These were used as reference to automatically classify humpback vocalisations in the overall dataset. 3. the performance of the automated detection process was tested with an independent sub-sample. Humpbacks were recorded during the breeding season, from end of December to April in all recording years. Most detections occurred in February and March and consisted of singing animals. This pattern was consistent between the years studied, suggesting that humpbacks return to the Saba Bank each year to breed. Humpback whales in reproductive areas tend to show exuberant surface behaviours that are hard to miss, leading to the question why, if there is indeed an returning occurrence of breeding whales, this was not described in the past. One explanation might be that Saba bank is comparatively far away from shore and has limited vessel-based tourism. In other areas those are often a source of opportunistic sightings of cetaceans. As a monitoring method, PAM can provide long-term potentially continuous data on cetacean acoustic activity in a specific location and yield valuable information on distribution patterns, habitat use, behaviour and changes thereof. In this case it has provided information that warrants a more in-depth look to determine the importance of this area as a potential breeding area for humpbacks. This is in particular relevant in the context of developing an effective cetacean management plan for the

Assessing intrinsic and seasonal variability in killer whale morphometrics, blubber thicknesses, and body condition indices via monthly assessments of trained individuals.

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Recent investigations on the endangered Southern Resident killer whale population have focused on assessing body condition and health. The primary tools used to assess body condition are photogrammetry for free-ranging killer whales and extensive morphometric and blubber thickness measurements for stranded individuals. Despite the reliance on morphometric measurements to assess body condition of killer whales, no controlled studies have been conducted to assess factors (e.g., age, sex, season, water temperature) that influence killer whale body condition indices (BCIs) and blubber thickness. To address this data gap, we recorded body mass, straight body length (rostrum to fluke notch), four girth measurements (eye, anterior and posterior pectoral fin insertions, anterior dorsal fin insertion), ultrasound-measured blubber thicknesses at six sites along the body, and various BCIs (e.g., each of the four girths/body length) from 21 killer whales at three oceanaria every month for one year. Daily water temperatures were also recorded. All morphometrics and body condition indices varied by age, body length and sex. Although blubber depth varied by site, with thicknesses at the dorsal and ventral sites being greater than at the lateral site, blubber thickness at all sites increased with body length. Blubber thicknesses also varied inversely with changes in pool temperature. All

four BCIs (girth/body length) decreased linearly with total body length, yet the slopes of the regression equations were significantly different. The steepest slope was observed for the relationship between body length and eye girth/body length. This demonstrates that this BCI is most affected by growth. The smallest slope was observed for the relationship between body length and anterior dorsal fin insertion girth/body length. These results provide data to inform interpretation of measurements used to assess body condition of free-ranging killer whales and suggest that evaluations of girth/length (or width/length for photogrammetric studies) body condition indices should be age-specific.

Results of real-time passive acoustic monitoring during the 2018 Pacific Region International Survey of Marine Megafauna (PRISMM) off Western Canada

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We present results for real-time passive acoustic monitoring (PAM) conducted as part of a large-scale line-transect survey of marine mammals in exclusive economic zone (EEZ) waters off the west coast of Canada. The offshore component of this, first ever, systematic survey of outer coastal waters was conducted for approximately five weeks, from July 5th to August 11, 2018, aboard the 69-meter Canadian Coast Guard Vessel, John P. Tully. This survey was conducted by Fisheries and Oceans Canada to assess the distribution and abundance of marine mammals. The real-time PAM components consisted of a four-element, towed hydrophone array and a sonobuoy system. In addition to making digital recordings, both systems were monitored 24/7 by experienced bio-acousticians. The towed array system was deployed for approximately 640 hours representing 78% of the time underway. Approximately 144 independent detections were made and classified to the highest taxonomic level possible. Sperm whales (n=53) and porpoises (n= 49) represented just over two-thirds of all detections. Localizations were made when possible, with ten localizations for sperm whales and 31 for porpoises, representing just over 60% of all (n=67) high quality localizations. Sonobuoy effort consisted of semi-systematic deployments, both during the day and night, and also during sightings of large baleen whales. Excluding three sonobuoys deployed during initial system testing, a total of 112 sonobuoys (type AN/SSQ-53F and AN/SSQ-53G) were deployed in DIFAR (i.e. directional) mode. Sixteen (14%) of sonobuoys failed for unknown reasons. Marine mammal calls were recorded on 32% (36) of sonobuoys. Detections included calls and whistles from killer whales, sperm whale clicks, dolphin clicks, fin whale calls, and blue whale calls (both B and D type calls). More detailed results will be presented with examples of acoustic detections, localizations and unusual bioacoustics signals recorded during this survey.

Marine Mammal Acoustic and Spatial Ecology (MAPS) research project: 'Physe-terrace', seasonal distribution of sperm whales (Physeter macrocephalus) in the western North Atlantic.

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The Marine Mammal Acoustic and Spatial Ecology (MAPS) research project, conducted in the winter and spring of 2019, investigated the behaviour and ecology of cetaceans inhabiting the Outer Continental Shelf (OCS) of U.S. Atlantic waters. Priority species for this project were deep-diving odontocetes, including sperm whales and beaked whales, which appear to be particularly vulnerable to anthropogenic acoustic activities. Key data gaps for these cryptic species include: vocalisation rates, diving/behavioural ecology, and a regional paucity of survey effort in the winter and spring, particularly in deeper, offshore waters (>1000m). These data are required to reduce the uncertainty in analyses of occurrence and density critical to the effective management and mitigation of OCS

species by regulatory bodies such as the Bureau of Ocean Energy Management.

As visual detection of deep-diving cetacean species is constrained by the limited proportion of time spent at the surface, the MAPS surveys were conducted using both acoustic and visual techniques. R/V *Song of the Whale* was used to survey 3,000km of equal spaced, zigzag transects in each season: winter (Jan/Feb) and spring (Apr/May). This provided an acoustic coverage of 54% based on an estimated half strip width of 10km for sperm whales. Sperm whales were only encountered in waters >300m and were found between the continental slope and the furthest limits of the study area (330km offshore) in 5000m deep water. Group sizes ranged from single individuals to socialising groups of at least 16 animals; all age and size classes were represented from ~4m neonates to large, heavily scarred males. Comparison of densities suggests higher numbers of sperm whales, and larger groups, on the OCS in winter months, supporting findings from previous acoustic studies. The MAPS surveys provide substantial new datasets for the region and establish a baseline for future monitoring efforts.

Oceanographic conditions predict at-sea behavioural states in a sexually size-dimorphic marine predator: The grey seal (Halichoerus grypus).

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Spatio-temporal variation in the oceanographic conditions of continental shelves results in a three-dimensionally patchy distribution of prey available to upper-trophic level predators. Although oceanographic features have been linked to the movements and foraging patterns of diverse taxa, fewer studies have used oceanographic data simultaneously collected by instrumented animals. We examined the influence of fine-scale oceanographic conditions on the foraging patterns of adult grey seals using *in situ* environmental data. To do this, we recorded data from 79 seals (20 males, 59 females) with Mk10-AF Fastloc™ GPS data-loggers during the period 2009-2015. These instruments recorded a total of 1,668,086 dives and 569,349 locations with associated water column profiles. Light level collected during the ascent phase of dives was used with a regional bio-optical model to estimate chlorophyll-*a* concentration. GPS locations were classified into two behavioural states (apparent foraging and directed movement) using the hidden Markov movement model. Using generalized linear mixed models, we examined the influence of upper-water column and bottom conditions on the behaviours of seals. In the upper-water column, season had no influence on the probability of apparent foraging behaviour, but chlorophyll-*a*, upper-water column temperature, and sex did, with females having a greater probability than males. In the bottom conditions model, again season had no influence on the probability of apparent foraging, but sex did with the odds of females foraging being more than twice that of males. There was a small effect of an increase in bottom temperature on the probability of apparent foraging in both sexes. We suggest that oceanographic features serve as an indirect proxy for the availability of prey and that grey seals may use these features to enhance foraging success.

Pathogen exposure surveillance in Southern Ocean pinnipeds

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An increased pressure of human activities that can introduce new infectious agents and therefore alter host-pathogen interactions, resulting in epizootics and biodiversity loss, challenges the Southern Ocean and Antarctica. Health status information and the potential effect of disease outbreaks in Antarctic fauna is scare and evaluating the susceptibility to new infectious agents is decisive for its conservation. Herein we assess the exposure of Antarctic fur seals (AFS, *Arctocephalus gazelle*) and Southern elephant seals (SES, *Mirounga leonina*) to pathogens known to be present in pinnipeds elsewhere. AFS (n = 65) serum and swab samples and SES (n = 13) serum samples from the sub-Antarctic island of Bouvet (54º41'S, 03º29'E) were collected in two austral summers (2014-2015, 2017-2018). Sera were assayed for *Toxoplasma gondii* and smooth *Brucella* antibodies with indirect enzyme linked immunosorbent assays

(iELISAs). Three PCR protocols for parapoxvirus DNA detection amplifying the DNA Polymerase, *B2L* and *GiF* genomic regions were performed. The genomic region encoding for glycoprotein B (gB) was targeted to detect Phocine herpes virus -1 (PhHV-1) viral DNA. Antibodies against *T. gondii* or smooth *Brucella* spp. were not detected, and no PhHV-1 amplicons were generated. Amplicons of the expected size were generated for parapoxvirus in two of the 29 AFS pups (nasal swabs, 2014-2015), for the *B2L* (n=2) and DNA Polymerase (n=1) genes, whereas the *GiF* PCR did not amplify relevant sequences. Sequencing of the PCR amplicons were carried out and blasted in GenBank finding most homology with a seal parapoxvirus, confirming the presence of the virus in AFS for the first time. In general, our data indicate that these seal populations are not threatened by being exposed to the pathogens tested, although parapoxvirus infections may cause severe disease in young and stressed individuals. Further, these data serve as a baseline for its future evaluation and management.

Don't hold your breath: Limited DNA capture using non-invasive blow sampling protocol for small cetaceans.

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Non-invasive conservation strategies currently used to monitor small cetaceans mainly focus on photo identification of individuals as a method to generate estimates of population status. With increasing anthropogenic pressures, in the form of renewable energy developments, fishing and tourism, there is the need for implementation of molecular techniques to more accurately measure population structure and health status of free-ranging cetaceans. Previous non-invasive DNA sampling has consisted of faecal, skin and exhaled breath (blow) sampling, with emphasis on the pathological information obtained particularly from sampling the blow. To date, blow sampling methodology has not been sufficiently optimised and thus scarcely applied to small cetaceans such as short-beaked common dolphin (*Delphinus delphis*) and bottlenose dolphin (*Tursiops truncatus*). In this study, we attempted to optimise a previously developed blow sampling protocol to enhance field sample collection and DNA recovery for both *D. delphis* and *T. truncatus*. Following previous recommendations, we streamlined the sampling approach to reduce the occurrence of avoidance behaviour and improve the precision for individual targeting. Overall, we collected 37 blow samples from *D. delphis* (n:30) and *T. truncatus* (n:7), however only managed to successfully extract target species DNA from one *D. delphis* sample, which is the first reported DNA detection of a small free-ranging cetacean from exhaled breath to our knowledge. Here we have highlighted the difficulty in obtaining DNA from wild cetaceans, despite improved collection success. We suggest future studies attempt to improve DNA detectability through using robust preservatives such as an ethanol-sodium acetate solution and employing adapted techniques which are compatible with the species being targeted. If this method is to be viable as a conservation tool for estimates of respiratory bacterial loads and population abundance of small cetaceans, further optimisation is required.

Fine-scale population structure and connectivity of bottlenose dolphins, Tursiops truncatus, in European waters and implications for conservation

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Protecting species often involves the designation of protected areas, wherein suitable management strategies are applied either at the taxon or ecosystem level. Special Areas of Conservation (SACs) have been created in European waters under the Habitats Directive to protect bottlenose dolphins, *Tursiops truncatus*, which forms pelagic and coastal ecotypes. The SACs have been designated in coastal waters based on photo-identification studies that have indicated relatively high site fidelity to these areas. However, individuals can carry out long-distance movements which suggest potential for demographic connectivity between the SACs. Previous studies on the species in this area used different sets of genetic markers and therefore inference on the fine-scale population structure and demographic connectivity has not yet been made at a wider scale. A common set of microsatellite markers was used in this study to provide the first comprehensive estimate of genetic structure of bottlenose dolphins in European Atlantic waters. As in previous studies, a high level of genetic differentiation was found between coastal and pelagic populations. Genetic structure was defined at an unprecedented fine-scale level for coastal dolphins leading to identification of five distinct coastal populations inhabiting the following areas: Shannon estuary, west coast of Ireland, English Channel, coastal Galicia, east coast of Scotland, and Wales/West Scotland. Demographic connectivity was very low among most populations with less than 10% migration rate indicating no demographic coupling among them and suggesting that they should be monitored separately. The results of this study have the potential to be used to identify management units in this area and thus offer a significant contribution to the conservation of the species in European Atlantic waters. Future studies should prioritize obtaining biopsies from free-living dolphins from areas where only samples from stranded animals were available in order to reduce uncertainty caused by sample origin, as well as from areas not included in this study.

International efforts to advocate for the imperiled vaquita: Lessons learned.

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The vaquita (*Phocoena sinus*), the world's smallest and most endangered cetacean, is endemic to Mexico's northern Gulf of California. Only 10 porpoises likely remain, and the animal's extinction is virtually assured without bold, immediate action. Vaquitas face a single threat: entanglement in illegal gillnets set for shrimp and various fish species, including endangered totoaba. Totoaba swim bladders, highly valued for their wrongly-perceived medicinal properties, are illegally exported from Mexico to China by organized criminal groups. Successive Mexican administrations failed to stop gillnet use, and the current Mexican administration's "initiative" to save the vaquita lacks the short term public policies and enforcement capability needed to address this serious issue.

A range of legal, political and consumer-oriented tools have been used to advocate for vaquita. In 2015 the Animal Welfare Institute and Center for Biological Diversity petitioned UNESCO´s World Heritage Committee (WHC) to list the Islands and Protected Areas of the Gulf of California - vaquita habitat- as "in danger" due to the site suffering a "serious decline." The WHC gave Mexico until 2019 to improve protections for the area. In 2017 a campaign was launched, encouraging retailers and consumers to choose alternatives to Mexican shrimp until gillnet use stops and the vaquita has recovered. In 2018 a lawsuit filed against the current U.S. administration for failing to fulfill its mandate under the Marine Mammal Protection Act (MMPA) resulted in a U.S. court temporarily banning the import of gillnet-caught seafood from Mexico's Upper Gulf of California. This year, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the WHC are being urged to consider additional conservation measures for vaquita and totoaba.

As bycatch and illegal fishing increasingly threaten marine mammal species, this presentation will examine lessons that can be learned from efforts to save the vaquita.

Estimating the length of short-beaked common dolphins (Delphinus delphis) using laser photogrammetry off Ireland

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Short-beaked common dolphins occur in large numbers around the coast of Ireland annually but very little is known about this species life history at sea. It is thought that the species may segregate depending on age and gender at particular times of the year based on current bycatch records.

Obtaining total length estimates from free-swimming individuals may provide an insight into the species group dynamics that are reflective of the population's dynamics and status. The dorsal fin was identified as a potentially useful and obvious feature to base total length estimates from since it displays an allometric relationship to the species overall size. An easy to use, standardised scaled image procedure was developed to enable the collection of measurable data from dead individuals with known total lengths and/or genders using citizen scientists and researchers from May 2017 – present to efficiently gather data to be measured retrospectively while avoiding observer bias that may occur between individuals taking physical measurements. Images of live dolphins were taken using a pair of lasers set to a known scale off the Southwest Irish coast to enable non-invasive laser photogrammetry to be carried out. Measurements were made of both the dorsal fin height (DH) and base length (DBL) but DH was found to be the better predictor of total length using a polynomial regression. Currently, eleven live common dolphins have been measured that displayed indicative size estimates ranging from 1.83 – 2.18 m in length using DH as a predictor from 22 dead individuals. This technique has not been applied to common dolphins previously but it may provide new insights into group composition (age class), recruitment rates (number of juvenile length individuals) and potential sexual segregations within pods to improve our current understanding of the common dolphins at sea life history to aid conservation efforts.

Non-invasive blow and aerial imagery collection for genetic and photographic comparison of putatively discrete groups of humpback whales (Megaptera novaeangliae) in northern British Columbia, Canada.

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The humpback whale (*Megaptera novaeangliae*) is a panglobal balaenopterid that undertakes impressive annual migrations between seasonal breeding and feeding grounds. The North Pacific population is estimated to have surpassed pre-whaling numbers and may now find itself nearing carrying capacity, as recent studies suggest possible population stabilization or decline. Despite being one of the best studied and most successfully recovering baleen whale populations on Earth, we still lack adequate knowledge to fully assess the risks of coastal development in several remote feeding grounds where multiple breeding populations are thought to share foraging space. We have launched an effort to elucidate the population structure of a seasonally resident feeding aggregation within a fjord system in northern British Columbia, Canada, that is both proposed humpback whale critical habitat and a planned shipping lane. Long-term photo-identification surveys suggest that two separate social networks of humpback whales feed in this area using different foraging techniques in different microhabitats within the fjord system and at different times of year. We aimed to use non-invasive exhaled breath condensate (blow) collection to genetically assess which breeding population(s) contribute to this subpopulation, and to estimate the levels of interchange with feeding aggregations to the north and south. Using novel quadcopter drone technology, blow was collected for DNA extraction and LIDAR and aerial imaging was collected for ongoing assessments of whale nutrition and pregnancy rates. Here we present preliminary results on population structure, interchange, nutritional status, and demographics of these two putatively discrete feeding groups resident to the area. Deepening our understanding of this humpback whale subpopulation is particularly timely as we prepare to assess the impact of a recently approved liquefied natural gas (LNG) tanker route, which will be in daily use through the study region beginning in 2023.

Mark recapture distance sampling – new opportunities for acoustic platforms using recent advances in technology and software

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Distance sampling (DS, e.g. line or point transects) is a commonly used method for estimating wildlife abundance. One critical assumption is that all animals on the line/point are detected with certainty, often referred to as $g(0)=1$, where $g(y)$ describes the detection probabilities with increasing distance y from the line/point. Mark-recapture distance sampling (MRDS) allows $g(0)$ to be estimated. Here, two observation platforms are required where for the trial configuration platform 2 sets up trials for platform 1 requiring independence of platform 1 from platform 2. For the independent observer configuration, both platforms set up trials for the other requiring independence both ways. Ensuring independence is often challenging logistically or due to observation conditions or animal behaviour. We discuss new avenues in the MRDS context for improving independence using new or existing technology and software. Two example studies serve to illustrate the methods:

- Simultaneous visual and acoustic line transect surveys for offshore dolphins where visual and acoustic platforms set up trials for each other, the latter using a towed hydrophone array. We show that during a passing mode survey in the eastern tropical Pacific, estimated probability of detecting schools of rough-toothed dolphins (*Steno bredanensis)* on the trackline for both visual and acoustic teams were imperfect and declined with increasing Beaufort sea state.
- Acoustic surveys using multiple stationary sensors where for each sensor, detections on the surrounding sensors formed the trials. We illustrate the method using the example of bowhead whales (*Balaena mysticetus*) in the Beaufort Sea where acoustic detections were made using an array of sensors mounted on the sea floor. Call detections were matched between sensors and localised if detected by more than one sensor. We demonstrate how absolute detection probabilities decrease with increasing distance around the sensors and compare these with detection probabilities estimated using conventional DS assuming $g(0)=1$.

Context of blue whale vocalizations as determined via tag-mounted accelerometers.

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Blue whale calls are routinely detected via passive acoustic monitoring (PAM). At the Monterey Accelerated Research System hydrophone in Monterey Bay, for example, tens of thousands of each Northeast Pacific blue whale call type have been recorded over the last several years. However, open questions on calling rates and the behavioral context of distinct call types limit the population size and behavioral information that can be extracted from PAM datasets alone. Advances on these questions have been limited by difficulty in identifying the individuals producing acoustically-detected calls. Here, we use tag-mounted accelerometers to identify calling individuals in analysis of 41 tag deployments with simultaneous acoustics, video, and 400 Hz accelerometry on blue whales in Monterey Bay, CA from 2017-2018. The strength and consistency of calls in the accelerometer signal, plus paired whales that register calls acoustically but not on accelerometers, provides compelling evidence that accelerometry identifies calls produced by the tagged whale- however, other interpretations are also considered. 837 accelerometer-based A, B, C and D call detections were made over ~544 hours of tag deployments, including at least one detection in 12 of 41 deployments. A, B, and C calls were produced significantly more often by individuals in confirmed feeding pairs (2.52 calls/hour) than solo or presumed solo whales (0.05 calls/hour). In contrast to previous hypotheses, D calls were detected primarily at night rather than during daytime feeding bouts. Previously, A, B, and C calls have been presumed to be produced exclusively by males. Our new method provides a positive ID of the calling whale, allowing for matching the tagged whale to biopsy samples in 30 cases. The sex of these calling and non-calling animals will be reported. This individual-level analysis provides call behavioral context, calling rates, and caller sex identification- essential information for accurate interpretation of blue whale PAM.

Baleen whale faeces in the Azores

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Cetacean faecal samples have been used to study diet, steroid hormones, exposure to parasites and biotoxins, individual genetic identification and assessment of microplastic ingestion in whales and dolphins. Baleen whale faecal samples are not usually easy to collect. However, as in the Azores whale watching platforms spend long time on the water and run trips year-round, they provide great opportunities to collect these samples. We review the baleen whale faeces records registered from whale watching platforms around São Miguel (Azores) between 2012 and 2018. During the seven years of the study, there have been registered 48 baleen whale faecal records, all of them between March and July. Of them, 77% were of fin whales, 17% of blue whales and only 6% of sei whales. These data support the Azores as a potential feeding ground for fin whales, blue whales and sei whales during the spring. During the spring, we have also registered krill patches on the surface in several occasions and feeding behaviour of the three species. The different colour of the faeces of each species may indicate differences in their diets: mostly red for blue whales, wider range of colour from orange, brown to red for fin whales; and even with a small number of records, yellow for sei whales. Furthermore, we create an appropriate protocol to collect and store faecal samples during the whale watching trips. In 2019 we start to use this non-invasive method as a new source of information here in the Azores. Nowadays we are looking for collaborators to go forward with the analyses of the faecal samples.

A story of how a critical habitat of an endangered species is lost: The Mediterranean monk seal in the Northeastern (NE) Mediterranean.

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Protecting breeding caves are of primary importance for the conservation of endangered Mediterranean monk seals (MMS). Despite this fact a large scale marine terminal serving to a cement factory was constructed just 500 meters away from a well-known MMS breeding cave in Yesilovacık bay located in the south coast of Turkey (NE Mediterranean). In this study, effect of the marine terminal on seals was evaluated by camera-trap monitoring which enable to evaluate the cave use frequency and activity pattern through pre, during and post construction periods. Results indicated that the number of seals using the cave before the construction of the terminal was dramatically reduced. Seal activity in the cave significantly decreased during the construction phase. Two whelping events occurred in the cave during the construction phase were ended by disappearance of the weaned pups and carcass of one of these two pups was found in cachectic state in the proximity of the cave. No further pupping activity has been recorded in this breeding cave since then. Considering the position of the cave with respect the marine terminal (<500 meters), the tonnage of the vessels (>30000 GRT), their speed, and given that the ships maneuver in front of the cave, the estimated noise emission (174dB) were higher than the disturbance level (120 dB) given for the pinnipeds. This can be considered as a good example of the negative effect of anthropogenic underwater noise on the pinniped. The cave may perform its function again only by; i) enforcing strict measures, such as limiting the number and tonnage (<1500 DWT GRT) of the ships; ii) declaring a traffic free buffer zone around the cave (10 km); and iii) deploying some additional noise preventive measures, such as bubble curtains, during maneuvers.

Estimating the trend in encounter rate of humpback whales in the recent years in the western waters of Okinawa (Ryukyu) Island, Japan.

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Humpback whales in North Pacific migrate to their feeding areas in higher latitudes in summer as well as breeding areas in lower latitudes in winter, including Okinawa, Japan. Although the increase tendency of humpback whales have been reported for recent years in North Pacific, there is also a report that the encounter rate (ER) in Hawaii and Alaska is decreasing drastically in past few years possibly because of the climate anomalies. Using the data corrected through January to March off the coast of Kerama Islands and Motobu peninsula in Okinawa from 2009 to 2018, we investigated ER for humpback whales as well as ER for mother-calf pairs for evaluating the trend in ER of humpback whales in Okinawan waters. ER for each whales were calculated by dividing a total number of whales by a total number of days of surveys. As a result, a total of 4190 whales in 2209 groups have been sighted in 381 days in Kerama and 4004 whales in 2174 groups in 314 days in Motobu, respectably. The mean ER for whales for Kerama was 10.85 when it was 12.93 for Motobu during the

survey years and there was no significant increase or decrease tendency have confirmed for past ten years. The ER for mother-calf pairs was 0.51 for Kerama when it was 0.46 for Motobu. Although there was no significant trend confirmed for ER for mother-calf pairs, it also showed gradual growth in recent few years in both areas. Despite our result indicating that there was no serious decreasing tendency occurs in Okinawan waters in recent years as confirmed in Hawaii and Alaska, continue monitoring for the population tendency in Okinawan water is needed for effective conservation plan for the humpback whale population in North Pacific.

Fin and blue whale distribution, diet and zooplankton backscatter around Isla Chañaral, Northern Chile.

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Isla Chañaral is part of the Humboldt Archipelago, a chain of coastal islands off Northern Chile, and part of the Humboldt Current System (HCS), one of the most productive Large Marine Ecosystems on the planet, and one that sustains the highest fisheries catches in the world. Isla Chañaral is surrounded by a 1nm Marine Reserve and is a known feeding ground for fin whales, as well as blue and humpback whales, which also supports a growing community run whale watching industry.

This study aims to understand the spatial and temporal dynamics of fin and blue whales and their prey around Isla Chañaral, and to determine fin whale diet. Cetacean visual sighting surveys were carried out along line transects around Isla Chañaral, during February 2018 and February 2019. The survey boat was equipped with a side-mounted Acoustic Zooplankton and Fish Profiler (AZFP) sampling at 38 kHz, 125 kHz, 200 kHz and 455 kHz. We also use cetacean sighting data in and around the Marine Reserve collected by the Chilean Park Service (CONAF) between December and April, 2016 to 2018. Opportunistic fecal plume samples were collected with a dip net during focal follows of whales; these were then used for prey group identification. An Acoustic Doppler Current Profiler (ADCP) was deployed off Isla Chañaral between November 2017 and April 2019 to examine temporal variation in zooplankton backscatter. This is the first study that looks at zooplankton backscatter and whale diet off Northern Chile.

Here, we present the prey groups consumed by fin and blue whales. We show the spatial distribution of fin and blue whales in the Isla Chañaral area, with near shore and further offshore hotspots. We also present spatio-temporal dynamics of zooplankton backscatter in the Isla Chañaral area. Finally, we propose priority areas for Marine Reserve expansion.

Impact of fisheries on bottlenose dolphin behaviour in the Ría de Arousa (NW Spain).

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Interaction between bottlenose dolphins and fisheries is a growing problem worldwide. The fisheries sector in the Ría de Arousa (Galicia, NW Spain) is one of the most important of Europe, however the effect of fisheries activities on the behaviour of bottlenose dolphins (*Tursiops truncatus*) remains poorly known in the area. This study is a first approach to analyze the interactions between bottlenose dolphin and two type of fisheries in the Ría de Arousa: gillnets and fishing cages. The study was conducted from direct observations by boat from May to June 2017 by coupling presence of fishing activities with bottlenose dolphin behavioural data. Over a period of two months spent in the field, 15 daily boat surveys were carried out and 54 bottlenose dolphin groups were encountered. The results of this study show that bottlenose dolphins are present in the Ría de Arousa in presence and absence of gillnets and fishing cages. In addition, when gillnets and fishing cages were present, the behaviour of bottlenose dolphins changed significantly. In the presence of gillnets and fishing cages, bottlenose dolphins tended to reduce their social and feeding activities, and to travel more. These results are not consistent with predation behaviour on nets reported by many

authors for this species. This information has important conservation implication for the bottlenose dolphins present in this area.

Population assessment of the southern sea lion in the southeast Pacific between 18° and 48°S: New information for future stock assessment report.

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South American sea lion (SSL), *Otaria byronia*, range along the Pacific and Atlantic coast of South America. The species interact with the mainly export fisheries in Chile (Chilean silverside, Chilean jack mackerel, Patagonian toothfish, swordfish, hake, southern hake, Patagonian grenadier) and salmonculture (Atlantic salmon, coho salmon and rainbow trout). The aim of this study is to assess the population of SSL along the Chilean coast, for contributing to the stock assessment report associated to the Marine Mammal Protection Act and its Import Rule. During the reproductive season 2019, aerial photographic surveys were conducted between 18°S and 48°S covering more than 3400 km of coast. According to biogeographical and genetical information the population was divided in four prospective stocks: northern, central, southern and austral. In the study area a total of 242 colonies were registered, 102 in northern, 56 in central and 84 in southern Chile. The photographs are still under analysis, nevertheless based on survey data from 2012, 2013 and 2015 the population estimation was of 190,000 individuals, 95,000 in the northern, 28,000 in the central and 67,000 in southern stock. In the 3 zones the pups estimation was of 35,244 (59%); 2,063 (7%); and 22,832 (40%) respectively. This is the first time that a survey included three of the four prospective stocks in a reproductive season, so the new information will allow to calculate population trends, the Potential Biological Removal (PBR) and link this information with the bycatch for the main export fisheries to assess and reduce SSL mortality from incidental fisheries takes.

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From the shore to the stage: How stranded and bycatch cetaceans can provide knowledge, engage in conservation and foster awareness. The Galleria Cetacei of the Centro di Educazione Ambientale e alla Sostenibilità Laguna di Nora (Sardinia, Italy).

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Cetacean museum collections represent a major attraction for the public and play a fundamental role in delivering scientific knowledge and raising awareness towards the conservation of marine mammals. Since 1993, the Centro di Educazione Ambientale e alla Sostenibilità (CEAS) Laguna di Nora is involved - through its operating arm Centro Recupero Cetacei e Tartarughe Marine (CRCTM) and the network Rete Regionale per la Conservazione della Fauna Marina of the Regione Autonoma della Sardegna - in the monitoring, investigation, rescue and museal recovery of cetaceans stranded or bycatch along the south-western coast of Sardinia. To valorize the results of its activity in the field for educational purpose, the CEAS Laguna di Nora conceived and created the "Galleria Cetacei", a permanent exhibition of cetacean osteological specimens that functions as a work-in-progress, self-implementing museal laboratory. Hanging from the roof or placed inside wood-and-glass frames under a real-size sperm whale-shaped building, skeletons of Sperm Whale (Physeter macrocephalus), Common Dolphin (Delphinus delphis), Long-finned Pilot Whale (Globicephala melas) and Risso's Dolphin (Grampus griseus), as well as skulls and disarticulated bones from Bottlenose Dolphin (Tursiops truncatus) and False Killer Whale (Pseudorca crassidens) are displayed. Every specimen is inserted in a conceptual path of narratives and materials informing on its story and educating about the species natural history and conservation status. Multi-media and instrumentations guide the visitor through an interactive process of experiential learning. Specially dedicated to school-age students, the active participation to the operational workflow that brings newly-acquired osteological specimens from the disinterment, through the assembly and then the museal display, allows first-hand interaction with the CRCTM scientists and field operators. Overall, the Galleria Cetacei provides the visitor a unique opportunity to undertake a holistic cognitive and emotional journey that can shape perspectives and behaviors into sustainable actions towards marine mammals and the entire marine environment.

Oxygenating blubber: A challenge for fat animals.

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Large fat depots are associated comorbidities in humans. Biomedical studies show that tissue expansion leads to structural tissue modifications and potential hypoxia as result of low vascularity or impaired diffusion due to large adipocyte size. How blubber maintains adequate oxygenation and readjust tissue structure is unknown. Here, we examine blubber depth and fatness effects on tissue oxygenation and blubber characteristics. Blubber dissolved oxygen levels (pO_2) were measured in dorsal flank blubber on juvenile grey seals (n=10) under appropriate sedation and anaesthesia. Measurements were taken at different blubber depths, with an optical, non-consuming oxygen probe. Oxygen supply was investigated recording systemic blood saturation (SpO_2), breathing rate and oxy-haemoglobin and deoxygenated haemoglobin. The later was measured using a novel non-invasive technique: Near Infrared Spectroscopy (NIRS). Body composition and heart rate were also recorded. To examine vascularity and tissue structure changes throughout depth and fatness, full blubber depth biopsies of mother and pup pairs were taken at early and late lactation (n = 6). Biopsies were fixed in formalin, processed and stained with Masson's Trichrome. Each biopsy was divided into three sections, and five images of each section were analysed by Image J. *In vivo* oxygen measurements ranged between 11 mmHg and 59 mmHg (mean = 32 mmHg), consistent with levels on other species. Linear mixed effect analysis (LMM) showed that tissue oxygenation had a significant positive relation with SpO_2 (p-value = 0.04) and a negative relationship with depth section (p-value Inner vs Outer = 0.02; p-value Inner vs Middle = 0.17; p-value Outer vs Middle = 0.46) and fatness (p-value = 0.04), independently of the individual ($R^2_{marginal} = 0.59$, $R^2_{conditional} = 0.59$). Results show that tissue expansion is also a challenge for seals. NIRS and histology data analysis are underway to explore oxygen supply, vascularity and tissue structure role on oxygenation.

Cortisol concentrations in baleen from a suckling calf fin whale (Balaenoptera physalus)

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Baleen is a keratinized structure involved in feeding that is unique to mysticetes. Previous studies have demonstrated the ability of this matrix to accumulate steroid hormones, and the retrospective information of life history that these samples could offer. Hunt et al., (2017) showed that cortisol is detectable in baleen from eight whale species, including two specimens (subadult and unknown age) of fin whale (*Balaenoptera physalus;* Conserv Physiol. 5:1-14). The main objective of the study was to determine if cortisol is detectable in baleens from a suckling calf fin whale and to assess cortisol levels variation at different locations along the baleen plate, to determine in the future whether baleen might contain a record of the physiological events. Twelve baleens with a length of 9.25 ± 0.48 cm (mean ± SD) from the dorsal plate of a dead calf fin whale were used. The baleens were divided in three sections: proximal, medial and distal to the gingiva. Samples were mechanically pulverized, afterwards cortisol was extracted by a methanol-based method and analysed by enzyme immunoassay. Results demonstrated that cortisol concentrations from the proximal sections of the baleen plate were significantly higher (0.43 ± 0.19 pgCORT/mg baleen) than those from medial (0.23 ± 0.01 pgCORT/mg; *p-value* = 0.009) and distal (0.21 ± 0.03 pgCORT/mg; *p-value* = 0.001) sections. Similar results were obtained in 11 immature and mature bowhead whales (*Balaena mysticetus*), where cortisol levels were higher in the proximal sections of the baleen plate (Hunt et al., 2014. Conserv Physiol. 2:1-12). In conclusion, the highest cortisol concentrations from baleen of a suckling calf fin whale were detected proximal to the vascularized zone. Further studies are needed to determine how cortisol is deposited in the baleen and if baleen cortisol levels can be correlated with stress responses to past physiological events.

Skin lesions on the cetacean community of the Santos Basin, Brazil

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Cetaceans are indicators of environmental health. The skin condition analysis of these animals is a non-invasive tool, which enables the identification of lesions of different sources, such as intra or interspecific interactions, diseases and anthropogenic impacts. However, there are few of these studies off Brazil, especially offshore. In this study, we describe the occurrence of skin lesions on cetaceans, photographed in coastal and oceanic waters of the Santos Basin, Brazil, by Projeto de Monitoramento de Cetáceos na Bacia de Santos (PMC-BS), a project financed by PETROBRAS and demanded by IBAMA. Fourteen boat surveys were carried out from December 2015 to October 2018. We recorded skin lesions on animals from 22 species (7 mysticetes and 15 odontocetes) and classified them according to 13 appearance-based categories: nodules; open wounds; depressed round lesions; white patches; whitish velvety lesions; deformation; pox-like, lobomycosis-like, anthropogenic interaction, cookie-cutter shark interaction, ulcerative lesions, killer whale interaction and miscellaneous. The most frequent types of lesions were: cookie-cutter shark interactions (75% of the species), nodules (68%), white patches (64%), miscellaneous (64%) and open wounds (50%). The species that showed a greater variety of lesions were *Megaptera novaeangliae* (11), *Stenella frontalis* (11), *Tursiops truncatus* (10) and *Balaenoptera borealis* (8). Killer whale interactions and red patches were only recorded on *M. novaeangliae*. Lobomycosis-like lesions only occurred on *T. truncatus*. A *Stenella frontalis* had a rostral deformation of unknown etiology. Potential anthropogenic interactions were recorded for 7 species: *B. brydei*, *M. novaeangliae*, *Sotalia guianensis*, *Stenella attenuata*, *Stenella clymene*, *S. frontalis*, *Stenella longirostris* and *T. truncatus*. A Bryde´s whale had deep propeller scars on its back from a vessel collision, and at least six dolphins had their dorsal fins partially or totally mutilated by fishing gear. This study shows novel results, contributing to the health assessment of cetaceans in Brazil.

What do grey seals (halichoerus grypus) in New England really eat, and what is the best way to determine diet?

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Grey seals (*Halichoerus grypus*) appear to be a species at odds with commercial fisheries no matter where they live: Europe, Canada, United States. It is imperative that their diet is clearly delineated so that the overlap with commercial fisheries is known. Researchers use a number of techniques to determine pinniped diets which utilize different types of samples that represent varied time periods, cost and labor, and each with its own benefits and restrictions. We studied several of these techniques in an attempt to determine which yielded the best estimate of the grey seals' true diet, and compared their results. Four of the techniques utilized scat samples, which do not require physical contact with the seals, but only include the last few days of feeding: hard parts, prey species specific PCR-DNA, prey species specific quantitative PCR-DNA, and next generation DNA analysis (metabarcoding). Hard parts analysis allowed quantification of prey species proportion in diet and biomass, which the other techniques generally did not. However, the DNA based techniques found prey species not detected through hard parts, and next generation DNA analysis uncovered even more previously undetected species. These DNA based techniques primarily yield frequency of occurrence in samples. Other techniques require a sample taken from a restrained or dead seal. Stable isotope analysis revealed diet over months, however, it was difficult to differentiate between species with similar isotope ratios. Fatty acid/quantitative fatty acid, and stomach content analysis have the advantage that the individual sampled is known. All of these studies have indicated that diet can vary with sampling location, season, year, sex and age of the seal. Overall, there is agreement between techniques that US grey seals eat primarily sand lance (*Ammodytidae spp.*), flatfish (Pleuronectidae), and hake (*Urophycis* spp.).

Hide and RADseq: Revealing global population structure and genetic diversity in two enigmatic beaked whale species.

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Beaked whales have gained public attention due to their involvement in mass mortality events related to naval exercises, now known to be a result of their strong behavioral responses to predator and naval sonar sounds. Limited information is available on population structure in most beaked whale species. However, local studies suggest that some live in small, seemingly isolated groups which are potentially susceptible to genetic erosion. As anthropogenic impacts continue to increase, it is vital to establish the underlying level of genetic diversity, structure, and connectivity in beaked whale populations across their geographic ranges to assess potential population-level impacts of these activities. In this study, we use double-digest restriction associated digest (ddRAD) tag sequencing to investigate population genomics of two sympatric and globally distributed species commonly associated with adverse responses to anthropogenic sound, Blainville's (*Mesoplodon densirostris,* n=43) and Cuvier's (*Ziphius cavirostris*, n=129) beaked whales.

This first analysis of genomic diversity and differentiation in these species using nuclear single nucleotide polymorphisms (SNPs; Blainville's n=13988; Cuvier's n=25059) identified from ddRAD sequences revealed hierarchical structure in both species across their global ranges using clustering algorithms (TESS3r) and population genetic statistics. In Blainville's, individuals clustered first by Atlantic and Indo-pacific basins, further subdividing into 3 populations each (observed heterozygosity: Atlantic=0.102-0.107; Indo-pacific=0.125-0.128). Cuvier's clustered by Atlantic, Indo-pacific and Mediterranean basins, further subdividing into 5, 5 and 3 populations, respectively (observed heterozygosity: Atlantic=0.118-0.128; Indo-Pacific=0.109-0.123; Mediterranean=0.081-0.092). Overall, Blainville's populations show less genetic diversity than Cuvier's, however, the lowest diversity was observed in Cuvier's from the Mediterranean Sea. Each species also had a single, genetically admixed population consisting of individuals sampled from across the North Atlantic. This evidence for significant genetic structuring supports results from photo-identification studies suggesting that these two species live in small, resident populations that are genetically discrete, substantiating the need for appropriately scaled management measures.

Individual foraging plasticity of harbour seals in a tidally energetic habitat.

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Oceanography is an established driver of behaviour for multiple taxa. Features ranging from macroscale oceanic currents and fronts to microscale eddies and tidal boils have been linked to increased foraging effort. Highly dynamic marine ecosystems provide a series of relatively unique benefits (e.g. increased primary productivity and predictable prey distributions) and challenges (e.g. potentially high transport costs due to water currents) for foraging predators and they must seek to balance these to forage successfully and maintain suitable fitness for growth and reproduction. In dynamic environments, the identification of foraging behaviour is complicated due to the animal's observed movement pattern being necessarily a function of both the individual's movement and the movement of the environment immediately surrounding it. Here, we sought to investigate this by employing a discrete time, state-switching model (Hidden Markov Models) to quantify movement of harbour seals in a tidally dominated region of Scotland using GPS derived locations and tidal current corrected swimming behaviour. We combined estimates of locomotion, measured movement in both 'geo-space' and 'hydro-space', and investigated the effects of temporally dynamic environmental covariates on the probability of switching between behavioural states. We demonstrate the importance of considering temporally and spatially dynamic habitat variables when seeking to quantify animal behaviour and activity budgets in mobile environments. Further, we found significant plasticity in inferred foraging behaviour whereby seals switched between foraging tactics in increasing currents showing a) the ability of seals to respond to fine-scale changes in environmental conditions and b) the importance of these habitats as foraging areas for the study population.

Porpoise sex is literally kinky: Unique lateralized mating behavior coevolve with genital asymmetry in harbor porpoises (Phocoena phocoena).

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Lateralized mating behaviors have not been reported amongst mammals with one remarkable exception. Male harbor porpoises (*Phocoena phocoena*) sexually approach females exclusively on the female's left side, breach out of the water, and hook their lengthy penis around the female to her vaginal opening. To understand the evolution of this unusual lateralized behavior, we assessed the morphological shape and symmetry of post-mortem reproductive tracts of 10 females and 3 male harbor porpoises from the same population as the behavioral observations. Two-dimensional geometric morphometrics of the vagina and 3D models of the vaginal lumen and inflated filamentous penis tip were used to characterize and quantify genital shapes and assess the influences of asymmetry on overall genital shape. There was substantial individual variation in vaginal shape in 2D, which was not correlated with total body length. The vaginas demonstrated significant directional and fluctuating asymmetry. The vaginal lumens were highly asymmetric as a result of complex 3D spirals and vaginal folds with deep recesses that may curtail the depth of penile penetration through physical obstructions. The asymmetric shapes of the excised penis tip, vaginal lumen, and penis tip of free-swimming harbor porpoises were similar. We demonstrate that the left-sided sexual approach of males is necessary for the penis to deeply penetrate the vagina, and suggest that the reproductive anatomy of both sexes and their lateral mating behavior have coevolved.

De novo genome and transcriptome assemblies of the Caspian seal

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Caspian seals are an endangered landlocked, small bodied phocid that diverged from a shared ancestor with Gray seals (*Halichoerus grypus*) and Ringed seals (*Pusa hispida)* around 1-2 million years ago. However, the evolutionary history of this group is still not fully resolved. We have been working on the *de novo* genome and transcriptome assembly of the Caspian seal (*Pusa caspica*). Our datasets include short read Illumina HiSeq paired-end sequencing data (60x coverage), long read PacBio single-molecule real time (SMRT) and Oxford Nanopore real-time long read sequencing data (8x coverage and 30x coverage, respectively) in combination with Illumina HiSeq RNA-seq data from six different tissues. To date, assemblies have been produced using short-read only data which resulted in estimated genome sizes of 2.6 Gbp and N50 contig size of 3.4 Kbp, although the N50 of the assemblies is expected to increase by multiple orders of magnitude with the inclusion of the long-read data. Currently eight additional pinniped genomes are publicly available, and sequencing efforts for further seal species are underway. Together these sequencing resources will facilitate detailed analyses of the evolution and genomic basis of the highly diverse ecological and life-history traits observed within pinnipeds, with a primary focus on lactation strategies. The Caspian seal genome can be expected to provide insights into adaptations to the unique Caspian environment and, in combination with other genomes, may offer finer resolution to the evolutionary history of the *Pusa-Phoca-Halochoerus* clade. Further, effective population sizes (N_e) will be calculated from the genome assembly using Pairwise Sequentially Markovian Coalescent model (PSMC), to infer demographic variation and colonisation dates in relation to palaeoenvironmental scenarios. This presentation will report the current state of the genome and transcriptome assemblies, discussing the various pipelines implemented as well as preliminary analyses into the demographic history of Caspian seals.

Insights into the Brucella ceti genome

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Brucella ceti is a dominant but poorly studied marine zoonotic organism that causes infectious diseases in marine mammals populations worldwide. B. ceti is a close relative of the pathogen B. melitensis, and constitutes the second genus, together with B. pinnipedialis, of the Brucellaceae family clade that is capable to occupy the marine environment. The increase of reported infections in cetaceans together with the need of understanding their zoonotic potential and the impact in human interventions, led us to perform a comparative analysis of B. ceti genomes. Here, the seven available B. ceti sequences were compared to 115 genomes of all Brucella available in Refseq databank. Comparative genomic analyses revealed a high degree of similarity among the marine Brucella, as well as with other terrestrial strains, with extensive pseudogenization in marine Brucella despite a global 97-99% similarity at genome level. Peculiarities of aquatic strains were found in pathways related to energy, transport of metabolites and regulation of transcription. Differences between B. ceti and B. pinnipedialis were found related to cell wall, plasmatic membrane and motility. Genomic traits potentially driving geographical strains distribution and host preference did not show clear correlations. This study provides new insight into the B. ceti genome plasticity, identifying genes that may contribute to the evolutionary success of this organism in infecting marine mammal species and spreading through the marine environment

Harbor porpoise (Phocoena phocoena) annual and seasonal distribution in Skjálfandi Bay, Iceland. Using opportunistic data over the past 10 years (2009-2018) collected from whale watching platforms.

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The harbour porpoise (*Phocoena phocoena*) is present in Skjálfandi Bay (Iceland) all year long. Whale-watching activity reaches its highest point during the summer season due to the high

abundance of baleen whales coming into the area, with two main companies operating in the bay. Therefore, many of the studies previously conducted here over the years have focused on these other species. This study aims to gather all the data collected over the past 10 years to give an estimation of the annual and seasonal distribution of this species in the bay in relation to the survey effort carried out. Thus, the kernel distribution analysis showed a clear hotspot for harbour porpoises on the west side of the bay, which might be related to the fish abundance as this area appears to be relevant for other cetacean species too. Additionally, a correlation analysis will be carried out with environmental variables such as tide, depth, slope and day time to assess whether the presence/absence of harbour porpoises could be related to them. The outcome of these analyses would be interesting in order to conduct further studies of this species in the North of Iceland and for future conservation and managing purposes.

Cetacean abundance and distribution in the northern Gulf of Mexico after Deepwater Horizon oil spill

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Line-transect vessel surveys were conducted in the oceanic northern Gulf of Mexico during 2017 and 2018 as part of the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS) to obtain updated information on abundance and distribution of cetaceans. We compared data from GoMMAPPS to data from two similar surveys collected prior to the 2010 the Deepwater Horizon (DWH) oil spill. Surveys were conducted over the continental shelf and oceanic waters, from the 100m isobath to the U.S. economic exclusive zone boundary, in summers of 2003, 2009, 2017, and 2018 and winter of 2018. We pooled sightings of oceanic dolphins, primarily from the genus *Stenella*, to estimate relative abundance as the total number of individuals divided by the km of survey effort. Geographic distribution of oceanic dolphins did not change over the years; however, relative abundance decreased from an average of 0.816 individuals/km in the 2003 and 2009 cruises to 0.495 individuals/km in the 2017 and 2018 surveys. This decrease raises important questions about potential effects of the DWH spill and should be further examined. Distance-sampling analyses are being conducted to compare bias-corrected pre- and post-DWH cetacean abundance estimates.

SEAFARI: Facilitating citizen science and stranding response.

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SEAFARI is a non-profit effort to encourage and facilitate public engagement in marine mammal studies and rescue. Taking advantage of the omnipresence of smart phones, SEAFARI is an app freely available for both iOS and Android. It allows users to log sightings of marine mammals anywhere in the world, and provides them with some information on the species. Information such as GPS position, behaviour, group size etc. as well as pictures can also be submitted. All sightings are then confirmed manually by the app administrator. All data collected via the app are freely available to researchers upon request. No personal information on the users is shared, but should there be a need to contact a particular user then this request can be made with the administrators. SEAFARI was created in South Africa, and best covers local species, but new species descriptions are being added and we do encourage users to submit sightings from all over the world. Currently a large effort is put into developing an easy way to report stranding and entanglement. The new function will provide a fast way to put users and local stranding response networks in touch, and hopefully improve the response. Taking advantage of the growing public interest in marine wildlife, this can be a great addition to costly fieldwork and help in the conservation of our megafauna.

Species-specific whistles in Delphinus delphis and D. capensis enable passive acoustic species identification.

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Short- and long-beaked common dolphins (*Delphinus delphis* and *D. capensis*) are sympatric species in the eastern north Pacific. These species are highly vocal and passive acoustic monitoring can be an effective tool for investigating their occurrence and behaviour. However, acoustic identification is challenging for these species, in large part because their whistles overlap in many time-frequency characteristics. In this study we analysed whistles from single-species acoustic recordings of *D. delphis* and *D. capensis* in Southern California. Recordings were made using floating buoys surrounding schools (sampling rate = 48 kHz). Species identification, school composition and school size were confirmed by visual observers, drone footage and biopsy samples. We extracted whistle contours and measured 52 variables from a random subset of whistles (*D. delphis* = 425 whistles, 9 schools, *D. capensis* = 464 whistles, 5 schools). Whistle contours were categorized based on frequency content and shape using dynamic time warping and artificial neural networks in ARTwarp. This analysis resulted in 212 whistle types, with 42% of these being shared between species. Of the whistle types that were produced by only one species, 23% (n=27) were recorded from more than one school and are likely to represent species-specific whistle types. Permutation tests showed that the proportion of species-specific whistle types was significantly greater than their proportion if sampled by chance from an assumed shared repertoire ($p<0.001$). Random forest analysis using a random subsample of all recorded whistles (n=425 per species) classified 68% of whistles to the correct species. Random forest analysis using only species-specific whistles (n=31 whistles per species) correctly classified 89% of whistles, suggesting that these whistles carry more species-specific information than others. This shows that species-specificity in whistles may be expressed by unique contours or parts thereof and may be missed by traditional global parameter measurements commonly used in acoustic classifiers.

Insights into the intestinal microbiota of the West Indian manatee (Trichechus manatus)

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The intestinal microbiota is essential for the metabolism in herbivorous mammals, releasing simple sugars from the complex plant polysaccharides, as is the case of cellulose (which comprises 70% of plant biomass). The crystalline structure of cellulose makes it resilient to biological hydrolysis, but certain bacteria and fungi in the microbiota are able to hydrolyze it through cellulases activities. With the notable exception of ruminants, little is known about the intestinal microbial diversity from herbivorous vertebrates. In this study, we characterized the intestinal microbiome of the West Indian manatee *Trichechus manatus*, a strictly herbivorous aquatic mammal. Fecal samples were obtained from two manatees under human care. Half of each sample was diluted and cultured to isolate cellulose-degrading bacteria. The other half was used for total DNA extraction and shotgun genomic sequencing, as well as 16s amplification, followed by DGGE, run for band cutting and direct sequencing. Amplification and sequencing of the 16s established the presence of phylum Firmicutes genera, followed by Proteobacteria and Actinobacteria. Shotgun genomic sequencing resulted in 11.676.441 unique reads among all four samples, from which, 454 OTUs were identified. Bacteria and 21% as Archaea were identified from 79% of the readings. Firmicutes were confirmed as the most abundant phylum, with 58% of the total readings, followed by 21% of the Archaea phylum Euryarchaeota, 13% to Proteobacteria, 5% to Actinobacteria, and less than 1% as Bacteroidetes and Verrucomicrobia. Alpha Diversity indexes were consistent with those reported from terrestrial herbivores (Shannon = 6.079 ± 0.06; Simpson = 0.04 ± 0.015) but the Chao Abundance Index was higher (Chao = 2489 ± 780). From the cultured portion of the microbiome, four strains with cellulolytic activity in CMC agar were isolated and identified as members of the genus *Klebsiella,* for which cellulolytic capacity has been previously reported.

Micro-anatomical and immunohistochemical characterization of the terminal portions of the lung in the sperm whale (Physeter macrocephalus), the fin whale (Balaenoptera physalus), and the bottlenose dolphin (Tursiops

truncatus)

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The lungs of cetaceans underwent physiological and anatomical adaptations that facilitate extended breath-holding during the dives, including the long and deep ones. On the contrary, the time spent at the surface for gas exchange is very short. Here we present our results on the relatively unknown micro-anatomy of the terminal portions of the lungs of fin (*Balaenoptera physalus*) and sperm (*Physeter macrocephalus*) whales. For comparison we examined also the most investigated lungs of the bottlenose dolphin (*Tursiops truncatus*). Our study focuses on small bronchioles, cartilage rings and alveoli. For this purpose, we executed routine histological techniques, and performed both an in-depth immunohistochemical (IHC) characterization, and a morphometric analysis of the terminal portions of the lung. For the IHC analyses, we employed commercial anti-human antibodies (Abs) against *i*) smooth muscle actin; *ii*) smooth muscle myosin; and *iii*) desmin. Results revealed that, in the bottlenose dolphin, a system of myo-elastic sphincters (MESs) is present up to the alveolar end of the terminal bronchioles. This MESs system consists of a series of sphincters placed at short intervals that constrict the lumen and divide the airways in chambers. In fin and sperm whales, smooth muscle bundles (SMB) were observed throughout the terminal bronchioles until the entrance of the alveolar sacs. However, contrarily to the MESs system, these latter structures do not constrict the lumen. Cartilage rings were present until the level of the entrance to the alveoli in the lungs of all the species. On the other hand, the alveolar size and wall thickness varied greatly. All the Abs used showed positive immunolabeling in all species sections, except for the smooth muscle myosin, which was not detectable in the sperm whale tissues. The present study provides the first IHC and quantitative morphometric analyses of the terminal portion of the lungs in selected cetacean species.

Hair testosterone levels of Northern fur seals correlate with month and testicular morphometric parameters.

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Hair samples can be used as endocrine markers to assess the reproductive status of animals, as hair is known to reflect endocrine activities spanning several weeks or months prior to the time of collection. However, it is unknown whether pinniped reproductive status can be assessed from hair samples. Northern fur seals (*Callorhinus ursinus*) are found off Hokkaido, Japan during non-breeding season. Knowledge about the reproductive statuses of free-ranging seals provides important data to inform population dynamics analyses. Here, we show that sexual maturity of northern fur seal males during the non-breeding season off Hokkaido can be distinguished using hair testosterone levels. A total of 57 male fur seal hair were collected during the non-breeding seasons of 2011-2018. Time-resolved fluoroimmunoassays were validated for testosterone through parallelism and gas chromatography. We found that the testosterone levels of juvenile seals (age < 4) were significantly lower than those of mature seals (age ≥ 4). Elongated spermatids, the final phase of spermatogenesis, were present in the seals collected between April and June. The seals collected in May, as spermatogenesis progresses, showed the highest testosterone levels. Our overall model revealed that testis weight and month were significant predictors of hair testosterone levels. Our results demonstrate that the juveniles can be distinguished from mature males using hair testosterone levels in May, preceding breeding season. Hair testosterone levels of seals, thus, likely reflect endocrine activity at approximately the time of sampling. Data on male reproductive status enhances our understanding of fur seal ecology, such as distribution of the seals off Hokkaido during the non-breeding season, and clarifies the connection between non-breeding and breeding seasons. This method can be applied in various species of pinnipeds, and is especially useful for those that spend time offshore during the non-breeding season, since hair can be biopsied.

A review of Balaenoptera strandings in the East coast of South America

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The genus *Balaenoptera* comprises seven species and 15 subspecies with conservation status ranging from "Endangered" to "Least Concern" and "Data Deficient". Despite data from whaling and offshore cruises, much of information related to seasonal distribution and ecology of these whales in the southwestern Atlantic Ocean (SWAO) comes from analysis of beached carcasses. A review of published and unpublished confirmed records on *Balaenoptera* strandings along the east coast of South America (from ~12ºN to 55ºS), comprising six countries (Argentina, Brazil, Chile, Suriname, Uruguay, Venezuela) and the Falkland/Malvinas Islands was used to evaluate spatio-temporal ecological and habitat use patterns of these whales. A total of 196 strandings from the seven species were documented from 1865 to 2018. Records varied largely across species: *B. edeni*/*brydei* (n=81), B. *acutorostrata* (n=45), *B. bonaerensis* (n=23), *B. borealis* (n=19), *B. physalus* (n=18), *B. musculus* (n=9), and *B. omurai* (n=1). As expected, most of the species occur in higher numbers during winter and spring migration season to/from low latitudes. When all records were gathered, the permanence of *B. edeni*/*brydei* and some individuals of *B. acutorostrata* in the Brazilian coast year-round became more evident than previously. Moreover, analysis of a greater number of studies brought strength to different theories, such as a possible latitudinal sexual segregation of *B. bonaerensis* (especially of pregnant females) and a calving area of *B. borealis* in mid-latitude waters of the SWAO. Also, a hypothesis of a larger calving area (from ~17ºS to 35ºS) than previously expected for *B. acutorostrata* emerged from the compiled data. Finally, although stock structure and taxonomy still need to be better resolved for different species, the information about *Balaenoptera* strandings are now comprehensively organized and exposed considering a greater dataset than any previous review in the east coast of South America.

Gollum is dead: Presentation of a cetacean online relational database under a Creative Commons license.

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Databases are a key aspect of scientific research. They are of capital importance not only to store and organize data but to analyze and design long term research plans. Relational databases are of special interest as they are structured in different tables that are connected with each other. This fact allows an effective way of performing the CRUD (Create, Read, Update and Delete) operations using the Structured Query Language (SQL). Here we present a marine survey online relational database structure implemented in PostgreSQL, an open source database management system. It is hosted in an online server provided by ElephantSQL, allowing the CRUD operations to be executed from any device around the world using the SQL language. The online database can be connected to R statistical software through the server credentials (username, password, and server name), a fact that allows an easy and effective way to import and analyze the data. The database is structured in more than 50 tables and contains more than 20 years of data on cetaceans and birds from the Mediterranean and North Atlantic. This point makes it not easy to interact with the database structure directly so an interactive way of making the CRUD operations is also presented using the Shiny package from R Studio. The database and the data included are under a Creative Commons license, allowing its use by anyone.

Living together yet a life apart: The behavior, distribution and abundance of sympatric inshore bottlenose dolphin and pantropical spotted dolphin in Golfo Dulce, Costa Rica.

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In sympatric predators, range overlap is frequently assumed as a potential for competition. However, co-occurring organisms could have different ecomorphology and niche preferences, thereby minimizing competitive interactions and coexisting. This study analyzed the ecological characteristics (abundance, distribution and behavior) of inshore bottlenose dolphin and pantropical spotted dolphin in Golfo Dulce (Costa Rica), identifying patterns-processes that enable the

mechanisms leading to coexistence. Mark-recapture analysis was performed using four years (2011–2015: eight rainy-dry seasons) of photo-identification data collected systematically for bottlenose dolphins and three years (2011–2014: six rainy-dry seasons) for pantropical spotted dolphins. Under the most parsimonious and best-fitted model of Pollock's robust-design, which included the effects of temporary emigration, the estimate of apparent survival was higher for pantropical spotted dolphins (S≈1, 95% CI: 0.99–1), than for inshore bottlenose dolphins (S=0.90, 95% CI:0.85–0.92). Both dolphin species evidenced random temporal emigration pattern with no seasonal effect. Total abundance estimates were relatively more precise for spotted dolphins (highest coefficient of variation was 0.10) and did not exceed 400 individuals, than for the small local population of inshore bottlenose dolphin (highest coefficient of variation = 0.24, total population < 120). There are important differences in foraging strategies between species in terms of depths: individual foraging in shallow waters for bottlenose dolphins and deep waters for cooperative foraging of spotted dolphin, which provided insights on potential dissimilarities in prey captured - consumed. The latter agreed with the pattern of distribution of both species and the resource partitioning evidenced in the species distribution models. The coexistence of both predators in Golfo Dulce is linked to habitat heterogeneity, where critical habitats are spatially differentiated. The lack of fine-scale spatial overlap, highlights a process of coexistence for dolphins that are sympatric at the scale of Golfo Dulce, but within the Gulf there is fine-scale allopatry.

"Dolphin dictionary": Using a self-organizing map to categorize the whistle repertoire of a group of bottlenose dolphins and identify signature whistles.

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Defining the repertoire of a species is important in understanding its communication system. While delphinids generally have complex acoustic communication, the consistent and repeatable categorization of their vocalizations is difficult. In this study, we define the whistle repertoire of 11 wild Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) and identify individually distinctive signature whistles (SW) within it. We recorded vocalizations of provisioned wild dolphins at Tangalooma, Australia. Recordings from a hydrophone array were used with video footage and photographs to localize whistles and identify the vocalizing individual(s). We used a self-organizing map (SOM) to create an automated categorization of dolphin whistles and tested its performance in clustering whistles from individuals. A number of tests were performed to identify the optimal parameters for the SOM resulting in a map with 64 whistle categories. These were assessed using a method for identification of SW by their temporal production (SIGID), identifying those containing potential SW. Visual assessment of the categories was also performed to subjectively evaluate the similarity of whistle contours within each category. Categories with potential SW were confirmed as belonging to the same animal by localizing whistles from them consistently to one dolphin. The SOM performed well in clustering similar whistles together. However, due to an overrepresentation of some SWs, these were split across several categories. Out of the 64 categories, 27 were identified as containing SWs. In three of these categories, less than 75% of whistles were correctly assigned, based on visual assessment. Other categories, however, had an average of 96% accuracy. The SOM was found to be a suitable method for mass categorization of the dolphins' repertoire and assisted in further fine-scale SW identification. It provided a valuable first step in reducing the number of categories to be tested, while the definitive identification of SW could be achieved using other methods.

Wake up and smell the krill: Is fine-scale dimethyl sulfide (DMS) concentration correlated to prey quality or humpback whale distribution?

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Finding prey is essential to the survival of all animals. Phytoplankton produce dimethylsulfoniopropionate (DMSP) and when krill and other grazers consume phytoplankton, DMSP is released and breaks down into dimethyl sulfide (DMS). Some krill predators, such as seabirds, have been shown to be attracted to DMS, likely relying on it for navigation and locating krill patches in the ocean. However, much of the research on attraction to DMS has occurred with captive animals or at breeding colonies. Studies at sea have released DMS to determine whether a species shows a positive response towards the chemical. It is unknown whether natural gradients of DMS correlate with prey abundance or predator distribution, or whether baleen whales use DMS to locate prey. Baleen whales are thought to have retained their sense of smell, suggesting that DMS concentration in the air is a possible foraging cue. We used a newly developed analytical chemistry instrument to measure the concentration of DMS at a fine-scale (temporal = continuous to 10 minutes; spatial = continuous to 1000 m) in both air and water. We examined whether DMS concentration was correlated to prey distribution and quality (patch size and density) or to the distribution of humpback whales (*Megaptera novaeangliae*). This study is the first to directly assess the relationship between natural gradients of DMS concentration and whale prey distribution, providing an indication of whether DMS gradients are likely to be a reliable foraging cue for predators to locate high quality prey patches. In addition, we assess whether humpback whale distribution on a feeding ground is more strongly correlated to air-based or water-based chemical signals. Given the role of DMS in global climate regulation, understanding its impact on predator foraging behaviour will provide a mechanistic understanding of how species will respond to future changes in the ocean.

Preliminary investigation of humpback whales (Megaptera novaeangliae) in the Bazaruto Archipelago, Mozambique

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During September 2018, an Israeli research team of biologists and acousticians set out to survey the humpback whale (*Megaptera novaeangliae*) population around the Bazaruto Archipelago, off the coast of central Mozambique. The entire Mozambique and Madagascar region serves as breeding grounds for southern hemisphere hupback whales of 'Breeding Stock C', through 3 different migration routes, during the austral winter, with the population in question belonging to the 'C1S Breeding Sub-stock'. The project's main goal was to observe mother-calf interactions and record vocalizations between them. Surveys were carried out over 13 days and the team collected 872 images for photo identification, enabling the identification of 63 individuals, including 11 mother-calf pairs, as well as videos, both above and below water, for behavioral analysis. Upon reviewing the photos, an peculiar pattern emerged: 8 mature individuals (4 of them mothers) with fresh cuts on one or the other side, just below and behind their dorsal fins. Repetative abrasions at this body location have not been documented in other humpback populations and it is possible that this stock exhibits a unique behavior that causes the cuts. This expedition also preformed the first acoustic recordings for the C1S Breeding Sub-stock, distinguishing between two types of communication: male songs and social-calls, the latter for both mother-calf and competitive group interactions. As part of the project, an open-source Matlab toolbox for bio-acoustic data analysis and denoising was developed, available at https://github.com/mosheman5/deep_voice. This project comprises preliminary research on a unique and scarcely documented region, seting a baseline for future studies in this area, so as to gain insight into the social dynamics of the humpback whale population around this archipelago and in the Mozambique region in general.

Cetacean stranding records on the central Turkish Black Sea coast in May 2017 - April 2019

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Between May 2017 and April 2019, monthly stranding surveys were conducted along the coasts of Sinop Province in the central southern Black Sea. The study is the first regular stranding survey on the central coasts of the Turkish Black Sea, which is known for intense artisanal and industrial fishing activities. During the study, the sandy beaches of the total length of 14.5 km were surveyed within the 63 km-long coastline. Stranded cetaceans were recorded, photographed and measured. Beside the surveys, media and citizen reports were analyzed, which constituted 28.5% of all records. In total, 42 stranded cetaceans of three species living in the Black Sea were found –23 common dolphins (55%), 15 harbour porpoises (36%), 3 bottlenose dolphins (8%) and 1 unidentified specimen. The highest number of strandings was recorded in spring, that is, in April (50%), followed by May (21.4%) and March (19%). The number of stranded individuals per km in spring months were as follows: 0.62 in May 2017, 0.55 in March 2018, 1.24 in April 2018 and 0.21 in April 2019. After spring, most of the strandings were seen in autumn (7.14%). More than half of the strandings were at an advanced stage of decomposition (stage 4 and 5, 60%), which made it impossible to determine the cause of death. In total, 13 individuals (31%), all of which were recorded in spring (9 common dolphins, 2 harbour porpoises, 2 bottlenose dolphins), were considered to be incidentally caught due to net marks on their bodies and missing fins/tail flukes. High number of stranded cetaceans in spring, especially in April, is considered to be related to the increased use of turbot gillnets in these months. Additionally, in spring being the ending period of industrial fishing season, purse seiners may also be another cause of mortality for those cetaceans.

Be prepared for muddled messages when monitoring management effectiveness in the face of sample noise and a changing environment

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North Atlantic right (Eubalaena glacialis, NARW) and humpback whales (Megaptera novaeangliae) are vulnerable to human impacts along the East Coast of the United States, The NARW population is in decline, both in abundance and divergence in sex ratio with males becoming more numerous than females. Humpback whale population growth in the Gulf of Maine has declined and is among the lowest rates on record for the species. The U.S. National Marine Fisheries Service has implemented a series of mitigation measures to try to reduce the impact of commercial fishing activities on the recovery potential of these species. Most notably, federal rules in 2009 and 2015 aimed to reduce the profile of ground line and the number of vertical lines in the water column, respectively. Stakeholders, including the fishing industry, scientists, conservation groups, and the agency itself are highly interested in the effectiveness of these actions. A metric frequently chosen to evaluate the effectiveness of rules for reducing serious injuries and mortalities due to gear entanglement (SIME) has been the annual count of observed events. Unfortunately, these count data are often viewed without regard to the sampling and stochastic processes that generate them. Herein, we evaluate the SIME counts, as well as vessel-strike related SIM, in a common framework for accounting for their inherent noisiness. We show that the signal in these data to date is inconsistent with the desired goal of reducing entanglement mortality and serious injuries since the ground line and subsequent rules were established. For right whales, these data actually imply that SIME has increased over time. We use this observation as a springboard to pontificate on the perils of attempting to gauge effectiveness in a setting that lacks replicates and controls of influences unrelated to the management action.

Diet shape the gut microbial composition of the Pacific harbor seal (Phoca vitulina richardii).

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Diet is a primary driver of the gut microbial composition and is considered one of the main routes of microbial colonization. Prey identification is fundamental to correlate the diet with the presence of particular microbial groups. This study examined how diet influenced the gut microbial composition and function of the Pacific harbor seal (*Phoca vitulina richardii*), a pinniped that predominantly consumes fish and cephalopods. The aim of the study was to understand the role of prey consumption on shaping the gut microbiota of harbor seals.

Twenty fecal samples were collected from five harbor seal colonies located in Baja California, Mexico. The V4 region of microbial 16S rRNA genes was amplified and sequenced using the Illumina MiSeq platform. DNA metabarcoding of the fecal samples was used to identify the preys

consumed by harbor seals. The gut microbiota of harbor seals was dominated by the phyla Firmicutes (37%), Bacteroidetes (26%) and Fusobacteria (26%). There were significant differences in the gut microbiota composition between the harbor seal colonies. PICRUSt was used to predict gene content in the gut microbiome and suggest a high content of routes involved in the metabolism of organic molecules. All harbor seal colonies presented routes related to the degradation of persistent environmental pollutants. Functional redundancy in the seal gut microbiota was observed regardless of diet or location.

There was a significant relationship between the diet and the gut microbiota composition and also with OTUs assigned to a particular metabolic pathway. The results of our study indicate that the frequency of occurrence of specific preys plays an important role in shaping the gut microbial composition of harbor seals by influencing the relative abundance of specific genera and phyla of gut microorganisms.

Energetic budgets of gray whale mother-calf pairs on their breeding ground in San Ignacio Lagoon, Mexico.

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In order to optimize the conservation of a species, it is important to understand how individuals allocate energy to the various phases of their life cycle. In the case of mysticetes, migration and breeding are taxing on females and quantifying the energetic costs associated with these behaviors can help inform management on the importance of certain habitats. Gray whales (*Eschrichtius robustus*) carry out some of the longest migrations ever recorded. This project aims at quantifying the energetic budget of female gray whales and their calves on their breeding ground in San Ignacio Lagoon, Baja California, Mexico. Non-invasive archival tags (DTAGs) were deployed on both females and their calves to quantify diving behavior, acoustics and energetic expenditure using respiration rates as a proxy. A total of 10 tags were deployed: five on adult females and five on calves. A total of 70 hours of recording were collected and focal follows on two mother/calf pairs were conducted for a total of seven hours. We present preliminary results on dive profiles, minimum specific acceleration (MSA) and acoustic behavior of these animals. Results will be compared to available and equivalent datasets from humpback whale (*Megaptera novaeangliae*) and southern right whale (*Eubalaena australis*) breeding grounds, thereby providing insights on the importance of these areas across mysticete species. In addition, results will provide a better understanding of the specific adaptations to long distance migration and gray whales' resilience to anthropogenic stressors.

First comparisons of testosterone levels in male humpback whales (Megaptera novaeangliae) of different behavioral roles and body sizes in the breeding grounds

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In the animal kingdom, a direct relationship between male testosterone and dominance appears complex, having been demonstrated in some species but not in others. It is well known that male humpback whales in the breeding grounds engage in physical contest competition for access to individual females. Within these competitive groups, the male successfully defending the position closest to the female (the principal escort) tends to be larger than other "secondary escort" males, and thus may be considered to be in a position of at least temporary dominance. However, whether the advantages of the principal escort role are also reflected in testosterone level is unknown. We measured testosterone in blubber samples obtained using biopsy techniques from 161 male humpback whales in various behavioral roles including 20 principal escorts (PE) and 47 secondary escorts (SE) in waters off Maui from 2004-2006 (Range = 0.30-4.31ng/g). There was a significant reduction in testosterone for both PE ($r = -0.60$, $p=0.005$) and

SE (r = -0.36, p=0.012) across the breeding season. Given this trend, we compared testosterone levels early in the season (Jan-Feb) from PE (Median = 1.13ng/g, IQR = 0.77) versus SE (Median = 1.17ng/g, IQR = 1.08), and also late in the season from PE (Median = 0.34ng/g, IQR = 0.49) versus SE (Median = 0.75ng/g, IQR = 0.77), and found a significant difference only late in the season (Mann-Whitney U, Z = -2.37, p=0.018). However, for five males in different behavioral roles sampled early in the season in which both testosterone (Range = 0.52-1.14ng/g) and body length (Range = 10.90-13.29m) were measured, the two were significantly positively correlated (r = 0.85, p=0.034, one-tailed). Taken together, these findings suggest that blubber testosterone may be reflective of male body size, but alone, may be a more subtle predictor of male dominance than size.

Regional differences in the cranial morphometry of adult male Galapagos sea lion

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The skull is useful tool that shows adaptation effects of species to different ecological and environmental influences. Based on the fact that the food available affects the somatic growth of the otariids, it was hypothesized that there could be regional differences between rookeries of Galapagos sea lion (GSL) as a result of the trophic recourses availability and the ecosystem variability in Galapagos Islands. Based on this, we used associated measures: (a) size, sections that define growth only; and (b) aggressiveness, specific sections of the skull that the individual uses in their antagonistic behavior. In this context, 34 linear measures, 20 in size and 14 in aggressiveness, were taken on 48 adult male skulls of GSL. Based in ecological information, the study area was divided into three bioregions: (a) Southeast (n = 15), (b) Center-North (n = 17) and (c) West (n = 16). Regional differences were observed, where the length of the nasal bone (p = 0.031), the width of mesodistal orbital (p = 0.022) and the width of occipital condyle (p = 0.025) were smaller in the western region. The length of the nasal, and the width of mesodistal orbital bone were associated to an increase in size, while the width of occipital condyle to a greater defense or aggressiveness of the males. The regional differences suggest a greater size and aggressiveness in the rookeries of the western region, which could be associated with a greater availability of resources and greater competition given the high variability of the ecosystem in the western region. The information generated in this work is important to understand the trends in the life history of the species, its opportunities and threats. Aspects that could be the basis to develop management measures for the conservation of this species.

The genetic legacy of extreme exploitation in a polar vertebrate

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Human exploitation is one of the greatest threats to global biodiversity. It is crucial to understand the consequences of human-induced declines on the demography and genetic composition of wild populations to predict species persistence and adaptive potential. We investigated the genetic legacy of large-scale commercial harvesting by reconstructing on a global scale the recent demographic history of the Antarctic fur seal (Genus). This species was hunted to the brink of extinction by 18th and 19th century sealers across their entire circumpolar distribution. Molecular genetic data from over 2,000 individuals sampled from all major breeding colonies show that at least four relict populations survived commercial exploitation around Antarctica. We used a coalescent-based approximate Bayesian computation framework to reconstruct this species' recent demographic histories and found that all of the populations experienced severe bottlenecks down to effective population sizes of around 200 to 300 individuals. Relatively high levels of neutral genetic variability of the Antarctic fur seal in

comparison to other Otariid species suggest that the inferred declines may not have been strong enough to have reduced allelic richness by more than around 15%. Our results indicate that the species as a whole was more resilient to hunting than suggested by historical accounts. Furthermore, the assertion is supported that only the strongest bottlenecks lead to major losses of diversity, and highlight the importance of relict populations to species recovery and the maintenance of genetic variation.

Harbour porpoise (Phocoena phocoena) mother-calf behaviour revealed by drone observations
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Due to their aquatic lifestyle and wide distribution, studying cetacean behaviours in the wild is difficult, especially when it comes to understanding their group structure and social behaviour. One of the less known species is the harbour porpoise (*Phocoena phocoena*). Despite being Denmark's only year-around whale, significant gaps still remain in our understanding of the behaviour and development of the species. Most of our knowledge comes from studies performed in captivity, and almost nothing is known about their social lives, group structure and bonds between conspecifics in the wild. Such information is of great importance for protecting porpoises, known to be vulnerable to by-catch and different types of pollutants, especially calves during the most vulnerable period of their life cycle. Unmanned aerial vehicles or drones represent an innovative and effective way to observe cetaceans in their natural environment. The aim of this study was to assess the affiliative relationship of mother-calf pairs by measuring the length and relationship (in terms of distances) between the mother and her calf in two different periods of the neonate's life cycle. Data analysis was performed from drone-based video recordings with the help of a new computer software developed at the University of Southern Denmark. During the first months after birth, calves stayed significantly closer to their mother and synchronized their breathing with her more often than during the final part of the lactation period. This shows that the bond between the mother and the calf is stronger during the first months after birth and gradually decrease during lactation. This has important implications for our understanding of harbour porpoise behaviour and how to design relevant and adequate conservation measures.

Applications of a new satellite-linked tag for long-term monitoring of large whale movements, diving, and feeding behavior.
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Despite spending much of their time on activities at depth, the technology in use to track whales over large geographic ranges via satellite has been largely limited to locational data, and most applications have focused on describing their horizontal movements, ignoring the vertical dimension. We describe the development of a new satellite telemetry device for tracking the movements and dive behavior of large whales over several months without requiring recovery. The tag incorporates sensors and software to detect dives and create per-dive summaries for transmission via the Argos System, and reports dive duration from a saltwater conductivity switch, maximum dive depth from a pressure transducer, and feeding events from a tri-axial accelerometer. Through three case studies involving humpback whales (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*) tracked while in their feeding areas as well as during migration, we demonstrate a variety of applications of the tag. We derived a suite of dive metrics from the dive summaries transmitted by the tags and documented diel and longer-term variability in diving and feeding behavior over tracking periods of up to 76 d. The results showed marked differences within and among individuals tracked contemporaneously, and provided some of the first assessments of previously unobservable behaviors in the context of movement across entire geographical ranges. This information has relevance to studies attempting to assess risk of exposure and response to anthropogenic noise and ship traffic and their relation to the animals' behavioral context. We conclude with a discussion of some of the tag's current limitations, including the importance of validation.

Ecological drivers of reproductive rates in humpback whales along the Western Antarctic Peninsula.
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Antarctic humpback whale populations are recovering after intense commercial whaling in the 20th century. Along the Western Antarctic Peninsula (WAP) this recovery is occurring in a rapidly warming environment. To fully assess the recovery of these whales, understanding the effects of environmental drivers on their demography is critical. Since the 1990s, biological and physical variability in this marine ecosystem have been described as part of the National Science Foundation's Long Term Ecological Research program. As part of this program, we have collected skin and blubber biopsy samples from humpbacks since 2010. We assessed pregnancy, via blubber progesterone concentrations, in 266 female humpbacks during the austral feeding season between 2010-2016. Using a Pearson's time series correlation, we found a strong positive relationship between pregnancy rates (year of birth) and the extent of summer sea ice in the same year ($r = 0.87$, $n = 5$, $p = 0.04$) and local krill abundance in the year of conception, i.e., one year prior to pregnancy ($r = 0.67$, $n = 5$, $p < 0.05$). These results are similar to observations made from other Antarctic krill predators (southern right whales and gentoo penguins) and reveal linkages between variation in the Antarctic climate and the biological processes driving humpback whale population dynamics along the WAP. These are some of the first quantitative observations linking the recovery of a baleen whale to ecological drivers in the Antarctic. Our results contribute to a better understanding of the effects of climatic change on whales and other large marine predators in the Southern Ocean.

The spatio-demographic trends of sperm whale (Physeter macrocephalus) strandings in New Zealand: A review.

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Despite the frequent sperm whale (Physeter macrocephalus) strandings in New Zealand waters, to date, there has been no review of their spatio-demographic trends. We used historical stranding records to assess spatio-temporal patterns of strandings on the New Zealand coast between 1873 and 2018. A total of 591 sperm whales stranded during 277 independent events. Using sex, age class, season and location, potential spatio-demographic trends were evaluated. Both sexes strand throughout all austral seasons and along all coast lines of New Zealand, in addition to two offshore islands. The majority of single stranded females occurred north of 44º S, which supports anecdotal distribution records of sperm whales within New Zealand. Of the strandings for which sex was determined (n=140), single strandings consisted of 39 females and 101 males (1:2.6). Austral summer (Dec-Feb) exhibited the highest (n=98) number of single stranding events. Across all seasons, the west coast had the highest number of single stranding events (n=111), followed by the east coast (n=94) and Stewart and Chatham Islands (n=24). All mass stranding events (n=23) occurred north of 44º S or on Chatham Islands (44.02º S). Mass stranding events for which group type was determined (n=18) consisted of 11 bachelor pods and seven matriline groups. Austral spring (Sep-Nov) displayed the largest number of mass strandings events (n=8) whereas austral autumn (Mar-May) had the greatest number of individuals stranding (n=151). The west coast recorded the highest number of mass stranding events (n=13), with eight of the 11 bachelor pods stranding on the west coast. Our preliminary findings suggest most live strandings included adult females. This is contrary to previous studies which indicate the New Zealand population consists predominantly of bachelor pods. Here, strandings data provide an invaluable resource to gain critical information about populations and species for which little is known.

Fine-scale movements of small cetaceans around an operational tidal turbine.

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The offshore renewable energy sector is expanding in order to fulfil ambitious national and international green energy targets in response to climate change. Tidal turbines harness energy from water currents and can provide more stable, predictable energy generation than wind or solar. However, there is increasing evidence that tidally energetic sites are important for marine mammals, leading to concern about potential collisions with turbine blades. To-date, there is a general paucity of information on the fine-scale movement behaviour of marine mammals around operational turbines to inform whether this concern is valid. This information is critical for regulators looking to effectively manage marine mammal populations whilst making consenting decisions about the tidal industry as it looks to develop from small, demonstration arrays to commercial scales. Here, we present results from a long-term (>1 year) passive acoustic tracking study of small cetaceans around an operational tidal turbine in the UK. A system of 12 synchronised hydrophones sampling at 500 kHz allowed fine-scale, 3-dimensional tracking of harbour porpoises (*Phocoena phocoena*) and dolphins. Real-time processing in PAMGuard reduced 365 TB of raw data to 1.2 TB of stored detection data. Twenty-seven dolphin and 571 porpoise encounters (>= 30 echolocation clicks) occurred in 12 months of monitoring. Marked seasonality in porpoise occurrence was evident; the highest detection rates occurred in December 2017 (mean = 3.1/day) and the lowest occurred in May and June 2018 (mean = 0.3/day). Porpoise detections occurred at all tidal states and during periods when the turbine was operational and non-operational. Preliminary tracking results indicate that between October 2017 and September 2018, 132 porpoise tracks came within 10 m of the turbine. We present the most comprehensive record to-date of 3D porpoise movements close to an operating turbine and discuss implications for collision-risk, and future management and monitoring.

Look up: Potential impacts of UAVs on Arctic Marine Mammals.

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The impact of UAV technology on marine mammals remains poorly documented despite the increase in their use for ecological studies. In polar regions such as the High-Arctic Archipelago of Svalbard, marine mammals are facing increasing pressure from the coupled effects of climate modification and an expanding tourism industry. Our study focussed on assessing UAV disturbance effects on marine mammals, conducting disturbance experiments to provide science-based management advice using a novel approach. We included a behaviour control period before and after experimentation which involved flying sets of profiles over a range of altitudes and approach strategies, using UAV models with varying acoustic profiles. Adult female polar bears responded to the take-off of UAVs even at ranges exceeding 200m, however response levels were relatively low and remained so even at 60m. Experimental flights over harbour seals during the pre-breeding and moulting seasons and over adult male walruses during summer aggregations yielded contrasting results. Pre-breeding harbour seals were the most reactive to UAV distance. Pre-experiment activity levels of walruses seemed to be the major factor influencing whether or not they were disturbed; when they did respond, young animals were the first to react, triggering a flee response of the whole herd. Adult female polar bears responded to the acoustic signature of the drone from the launch point over 200m away, but exhibited a weaker response at closer range than seals. For pinnipeds, vertical descent was the approach strategy that caused the greatest impact. The alertness level of animals prior to operations appears to be a major factor determining sensitivity to UAV disturbance, and larger UAV models do not cause more disturbance when flying pre-set smooth horizontal profiles. We suggest that footage obtained from 80m has a high enough resolution for most scientific purposes.

Temporal patterns of a low-frequency baleen whale call from Diego Garcia waters in the Indian Ocean.

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Passive acoustic monitoring provides a window into understanding the occurrence and seasonality of cetaceans in remote regions by studying their vocalizations. The Diego Garcia downsweep (DGD) described first by Sousa and Harris (2015) is a dominant baleen whale call type in the 18-50 Hz band recorded from hydrophones that are part of the Comprehensive Nuclear-Test-Ban Treaty off Diego Garcia Atoll. This study uses a decade of data (2008-2018) from these hydrophones to examine potential species identity of the signal and report on the inter-annual, seasonal, and diel

patterns of this call off Diego Garcia Atoll. Based on comparisons with recordings from Madagascar and western Australia, we believe these signals to be produced by Omura's whale (*Balaenoptera omurai*). The other possibility is Bryde's whale (*B. edeni*). Long-term spectral averages were used to examine annual and seasonal patterns from 2010-2017 and 2010-2014 at the southern and northern hydrophone which monitor the southern and north western Indian Ocean, respectively. Spectrogram correlation was used to build a detector that identified DGD calls from the time series. Parametric statistics using model approaches was used to examine predictors (e.g. year, season, time of day and interactions) of call detections. In general, detections peaked in austral winter on the southern hydrophone but austral summer on the northern hydrophone. There was significant interannual variability in the number and timing of call detections. This study provides new information on a (likely) recently described species of whale over a long time-series in the northern and equatorial Indian ocean region where visual surveys and information on baleen whale ecology are wanting.

The ACCOBAMS Survey Initiative - a tool to facilitate conservation effort across cultural, social and political boundaries.

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Simone will describe the genesis of the ACCOBAMS Survey Initiative: a synoptic survey to estimate density and abundance of cetaceans and large vertebrates in the Mediterranean and Black Seas. He will then go through the difficulties encountered during the funding and the preparation and implementation phases. Emphasis will be given on the rather complicated and diverse environment in the area, with multi-boundaries and cross-cultural situations. A glimpse on the results and conservation outcome will end his presentation.

The ACCOBAMS Survey Initiative: The first synoptic survey of the Mediterranean Sea.

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The "ACCOBAMS Survey Initiative" (ASI) is a pilot programme aimed at establishing an integrated and coordinated monitoring system for cetaceans throughout the entire ACCOBAMS area. Conducted in coordination with riparian countries, it supports the implementation of European and regional policies, in particular the Marine Strategy Framework Directive (MSFD-EU) and the Ecosystem Approach process (Barcelona Convention UNEP/MAP).

In summer 2018, a synoptic survey was carried out across the Mediterranean Sea and contiguous Atlantic area, combining visual methods (aerial surveys) and visual and passive acoustic monitoring (PAM) from vessels (focused primarily on deep diving species and areas where aerial surveys were not possible). Line-transect sampling methodology was applied and density and abundance estimated through design-based and model-based approaches.

Uncorrected for availability and/or perception biases, design-based estimates are available for the areas covered by aerial surveys, including: fin whales (N=1769, CV=0.28), sperm whales (N=1448, CV=0.51), Risso´s dolphins (N=26,659, CV=0.29), bottlenose dolphins (N=75,762, CV=0.21), long-finned pilot whales (N=5866, CV=0.41), striped dolphins (N=418,589, CV=0.14), common dolphins (N=65,925, CV=0.40), and a merged category of either striped or common dolphins (N=218,289, CV=0.27).

To continue this pivotal research effort, an equivalent aerial survey is planned for summer 2019 in the Black Sea in relation to the MSFD.

The 2018-2019 effort will provide an overall picture of the distribution and abundance of cetaceans throughout the ACCOBAMS area,

providing robust estimates to be considered as a baseline for further regional systematic monitoring programmes, coordinated and comparable amongst all areas. These data will improve the current knowledge on cetacean status, facilitate the development of targeted conservation and mitigation measures and allow for the follow-up to international obligations (EU, UNEP-MAP). Moreover, they will be used to support both place- and threat-based conservation efforts in the Agreement area, with the identification of Important Marine Mammal Areas (IMMAs) and Cetacean Critical Habitats (CCHs), respectively.

Mediterranean monk seal habitat use in the Central Ionian, Greece

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Projects for the conservation of the Mediterranean monk seal in the Ionian Islands of Kefalonia, Ithaca and the islets of Atokos, Formicula, Kalamos, Kastos and Meganisi started in 1985 and were regularly carried out until 2002. Over that period, 140 marine caves/overhangs were registered and were surveyed on a regular basis with respect to habitat availability and the use by monk seals. A total of 40 caves/overhangs were found to be used at least once: 16 caves were regularly used, in 5 of which pupping was registered. In 2018, a photo-identification project was launched in this area aiming at (a) establishing actual seal numbers and (b) updating the use of caves. After thorough cave surveys (continued throughout the project), in May 2018 infrared cameras were installed in 8 caves out of those used most frequently in 1985-2002 including 4 of the 5 pupping caves, thereby strategically covering the entire study area. Up to November 2018, evidence of use was registered in 7 out of the 8 caves monitored. Thus, the general pattern of cave usage has not changed substantially since the aforementioned early studies, contrary to information on the situation from other parts of Greece. Only in 4 out of the aforementioned 16 caves, no evidence of seal use was recorded, all of them in W. Ithaca where coastal development/tourism have significantly increased compared to the past. Three out of the five known pupping sites were found to be still used for pupping including one cave not monitored by cameras. Up to six animals were recorded together in the same cave while previously only up to three seals were recorded simultaneously in a cave. These findings highlight the crucial importance of this area in the overall conservation and recovery of the species, particularly with respect to the Adriatic-Ionian region.

Acoustic response of bottlenose dolphins (Tursiops truncatus) to airgun noise in the Adriatic Sea (Italy)

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Underwater airgun impulses can generate both acute effects, such as temporary/permanent threshold shift in marine mammals hearing, and behavioral reactions. Dolphins are able to adjust their communication signals in relation to fluctuating noise from natural or anthropogenic sources; however, little is known about the variation of communication signals during prolonged exposures to airgun impulses. This work aimed at evaluating the acoustic response of bottlenose dolphins to a continuous low frequency airgun emission in the Adriatic Sea (Italy). We examined 37dolphins' acoustic detections, 10 of which, corresponding to 10.3 hours, were recorded during 87 hours of airgun activity, occurred at about 180 km in Montenegrin waters, from 21th to 27th November 2018. 3D seismic surveys began off the coast of Montenegro on November 11th and ended on December 19th, 2018, using airguns firing approximately every 8 seconds at a depth range of 50–100m. Whistles occurrence and acoustic structure in presence of airgun noise were analyzed in 6 detections and compared to the ones collected in its acoustic absence, during the days before and after the emissions recorded. Whistles frequency parameters were modeled as a function of the intensity of airgun impulses. A higher whistles' occurrence was documented during airgun activities than in their absence, as well as the presence of different signature whistles, a greater whistles' modulation and diversity. These findings seem to indicate an increased communication effort by bottlenose dolphins, outlining a way airguns could potentially affect species' sociality and ecology through direct/indirect paths. The behavioral

responses of dolphins to acoustic stimuli vary widely depending on species, context, and properties of the stimuli. This study could help to better understand the extent to which bottlenose dolphins alter their vocalizations in the presence of airguns and provide evidences for predicting its potential effects on populations.

What whales say at night: Diel trends in the acoustic behavior of humpback whales on the North Atlantic feeding grounds.

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Humpback whales are known for their diverse acoustic repertoire. Numerous studies have explored the spatial and temporal production of song by this species. Less is known about the non-song vocalizations used in social interactions on the feeding grounds. Significant diel trends in sound production have been described in many other baleen whale species, yet little is known regarding these temporal trends in social sounds produced by humpback whales in the North Atlantic, highlighting an important gap in our understanding of their acoustic behavior with relevance to passive acoustic detection. Previous studies have described primarily daytime acoustic signal production, with identification of two novel signal types recorded on some night tag data from the Gulf of Maine. In this study, we use suction-cup attached acoustic recording tags (DTAGs) to characterize the diel trends in acoustic repertoire usage of humpback whales in the Western North Atlantic on the feeding grounds off the coast of Massachusetts in the United States between 2016-2019. These tags record sensor and GPS data to provide temporal and spatial context to sounds produced by the tagged whale, combined with data on the acoustic environment experienced by the whales. We collected data including both day and night-time data from 8 humpback whales (19-45h recording duration) between 2016-2018, with additional deployments planned for the summer of 2019. We present an analysis of the acoustic repertoire by behavioral state recorded on the tags and assess the spatial and temporal trends in sound production in this habitat to explore variation in the acoustic behavior between day and night time periods.

Close-range received levels of Hawaiian monk seal (Neomonachus schauinslandi) underwater calls

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Aquatically mating phocids are known to produce underwater vocalizations during the breeding season. However, for the tropical Hawaiian monk seal (*Neomonachus schauinslandi*), the breeding season is protracted and underwater sound production has only recently been documented. This study provides the first amplitude estimates of underwater calls produced by a male Hawaiian monk seal. Spontaneous underwater vocalizations were recorded year-round from an adult male Hawaiian monk seal living in human care at Long Marine Laboratory, Santa Cruz, CA, USA. Six call types were identified. These were generally low-frequency, short-duration sounds with average peak frequencies ranging from 48 Hz to 292 Hz. Sound pressure level (SPL) was measured over the 90% duration of 20 to 40 calls of each type. Received levels at distances of 0 to 7 m ranged from 123 to 169 dBre 1 µPa. Mean SPL values per call type at distances of 0 to 7 m ranged from 137 to 153 dBre 1 µPa. Call types with relatively brief durations (< 600 ms) tended to have higher SPLs than the call types with longer durations (> 1300 ms). These bioacoustic data for Hawaiian monk seals can be used to determine upper boundaries of intraspecific communication ranges for these seals in different ambient noise conditions, and have implications for potential conservation and monitoring efforts using passive acoustics.

Assortative interactions revealed in a fission–fusion society of Australian humpback dolphins.

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Understanding individual interactions within a community or population provides valuable

insight into its social system, ecology, and, ultimately, resilience against external stimuli. Here, we used photo-identification data, generalized affiliation indices, and social network analyses to investigate dyadic relationships, assortative interactions, and social clustering in the Australian humpback dolphin (*Sousa sahulensis*). Boat-based surveys were conducted between May 2013 and October 2015 around the North West Cape, Western Australia. Our results indicated a fission–fusion society, characterized by nonrandom dyadic relationships. Assortative interactions were identified both within and between sexes and were higher among members of the same sex, indicating same-sex preferred affiliations and sexual segregation. Assortative interactions by geographic locations were also identified, but with no evidence of distinct social communities or clusters or affiliations based on residency patterns. We noted high residency among females. Models of temporal patterns of association demonstrated variable levels of stability, including stable (preferred companionships) and fluid (casual acquaintances) associations. We also demonstrated some social avoidance. Our results point to greater social complexity than previously recognized for humpback dolphins and, along with knowledge of population size and habitat use, provide the necessary baseline upon which to assess the influence of increasing human activities on this endemic, Vulnerable species.

Population identity and occupancy characteristics of humpback whales (Megaptera novaeangliae) in the New York Bight apex

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Cetacean research has historically been limited in the New York Bight apex (NYBA), which includes the Port of New York and New Jersey and adjacent waters. However, increased sightings, documented mortalities, and high levels of commercial and recreational activity suggest the need for a better understanding of humpback whales in this area. Opportunistic sightings and photo-identification data for 54 individuals from the New York City Humpback Whale Catalog were used to determine occupancy, occurrence, and annual return in the NYBA. Photographs were also shared with regional and basin-wide catalogs to determine the origins of these individuals and their exchange with other areas. Mean occupancy length in the NYBA was 30.5 days, mean occurrence was 2.3 days, and mean rate of return was 39.1%. Individuals photographed in the NYBA had sighting histories in the greater New York Bight area (Cape May, NJ and Montauk, NY) and in the greater mid-Atlantic region (Virginia). There were also matches to primary feeding grounds, including 36% (n=18) to the Gulf of Maine and 2% (n=1) to Newfoundland. Sighting records suggest that most individuals were immature when seen in the NYBA. There were within-season sightings with both Montauk and Cape May suggesting that individuals may utilize the entire New York Bight during the feeding season. The NYBA may be of increasing importance to juvenile humpback whales as a supplementary feeding ground.

The age of epigenetics: A molecular biomarker for ageing killer whales using DNA methylation patterns from skin.

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Age is a key piece of demographic data contributing to an understanding of the age structure of populations, and critical for interpreting the behavior, ecology and health of individuals. Accurate chronological age estimates improve our ability to parameterize population dynamic models, infer individual and population-level effects from contaminants data, and predict disease impacts across the population as a whole. Common approaches for wildlife age estimation include counting patterns of annually accrued cemental deposition in mammal teeth and wax in ear plugs for mysticete cetaceans. More recently, acid racemization of the eye lens has been used to estimate ages of balenopterids. Unfortunately, these methods rely on tissues collected during necropsy or post-mortem processing. Attempts to age marine mammals from skin samples using changes in telomere length over time has been filled with both promise and pitfalls, and the relationship between telomere length and age has been found to be very weak in many species. Development of molecular biomarkers of age that could be applied to tissue biopsies would be beneficial for a variety of applications. DNA methylation (DNAm) is involved in gene expression, and age effects on DNAm have been documented in humans, humpback whales and other mammals. Age-related patterns of DNA methylation (DNAm) can be used to construct so-called "DNAm clocks" to quantify these changes in methylation patterns at specific CpG sites across the epigenome. Using skin biopsies, we developed a DNAm clock for killer whales based on 111 samples from the endangered Southern Resident killer whale population, including 90 known age killer whales born since 1971. Based on 100s of CpG sites, we built a regression model that is able to predict the age of an individual with a precision of 2.42 yrs. This species-specific model demonstrates the potential of DNAm as a molecular biomarker for aging living cetaceans.

Examination of combined isotopic signals as evidence for oceanographic regime shift within the Gulf of Maine.

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Within the past fifteen years, the Gulf of Maine has experienced dramatic increases in temperature and impacts to the Gulf's marine ecosystem—including its population of baleen whales—are not yet fully understood. One hypothesis suggests that increases in temperature have reduced productivity, affecting prey distribution. Tracking changes in resulting prey choice is challenging; however, analytical methods such as stable isotope analysis (SIA) allow researchers to examine trophic dynamics in consumers over various time scales and assess ecological impact of possible oceanographic regime shifts. Here, we report the results of the first year of a five-year SIA study to examine the trophic dynamics of humpback (*Megaptera novaeangliae*) and fin (*Balaenotera physalus*) whales using samples collected *in situ* via a crossbow-delivered biopsy dart. The results were compared to those from a similar study, completed in 2003, prior to the latest warming period.

A multivariate analysis of our 2018 data suggests that fin whales (n = 2) have a lower trophic level signature in comparison to humpbacks (n = 13), similar to findings from prior to the warming period ($p < 0.0148$), specifically due to differences in $\delta^{13}C$ values ($p = 0.0384$). Although more samples are needed to increase statistical power, the 2018 isotopic signature for fin whales appears not to have changed since 2003. However, the 2018 isotopic signature for humpbacks appears to have shifted—specifically, $\delta^{13}C$ values have become significantly more negative ($p = 0.0002$), while $\delta^{15}N$ values have remained statistically similar. Using isotopic fractionation enrichment constants, humpback isotopic values map well to contemporary samples of Atlantic herring (*Clupea harengus*). Thus, we find that humpback isotopic values have changed to some extent over the past fifteen years. This may be because of changes in diet, or because of changes in prey isotopic values.

Social structure of bottlenose dolphins in the Hauraki Gulf, New Zealand

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The social structure of a population has been described as the content, quality and patterning of relationships among individuals within a group. It is a synthesis of how individuals interact with each

other and is an important determinant of the biology of the population, influencing fitness, gene flow, and spatial patterns. Dolphins are gregarious animals that form complex social structures, from fission-fusion societies to social alliances. The North Island population of bottlenose dolphins in New Zealand was thought to be restricted to a single location; where the dolphins have been intensively studied. Recent studies have shown that the Hauraki Gulf, south of this location, it is also an important area for them. For the first time, we examined the association patterns among individually identifiable bottlenose dolphins in the Hauraki Gulf and therefore the social network structure of the dolphins frequenting this area. Data for this study were obtained from the Hauraki Gulf bottlenose dolphin catalogue between 2008-2013. We (i) describe the social structure of bottlenose dolphin in the area, (ii) determine the duration of association among individuals, and (iii) assess preferred/avoided companions among individuals. Results showed that of the 159 dolphins photo-identified in the study area, all were linked by association in one large social network. In general, dolphins exhibit weak associations (Mean HWI= 0.30 [SD=0.14]); however, some dolphins can associate with particular dolphins in this area (Max. HWI= 0.81 [SD= 0.16]). The associations in this area appear stable in the first 50 days, slightly decreasing after 110 days, but dolphins can have long-lasting preferred companionship in this area. The best fitting model for preferred/avoided companionships was casual (short-term) acquaintances and constant (long-term) companions. In this area, 44% of the dolphins observed at a specific time with a given dolphin will form long-term associations.

Can sustainable whale watching update on occurance of protected species? The common bottlenose dolphin (Tursiops truncatus) case in Maltese waters.

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The Maltese Channel above the Tunisian plateau is known to be of high ecological importance in the Mediterranean region (Notarbartolo di Sciara, *et al*. 2017). EcoMarine Malta has been performing the first 'whale' watching activities in Maltese waters with the aims of sustainable tourism and collection of scientific data on protected marine species (listed in the Habitat Directive and other multilateral environment agreements).

Visual and acoustic surveys were conducted in 2017 and 2018 (between May and September) in territorial waters, in bathymetry of 100 and 1,000 meters and an approximate area of 366 Km^2. Daily tours covered circa 32 nautical miles and included both the northern and southern coastal areas. During the surveys, the species sighted is the bottlenose dolphin (*Tursiops truncatus*) (N=10, 100% of the sightings). 80 % of the sightings occurred around the south-east fish farms. No sightings were however recorded during the above-mentioned tours, near the northeast fish farms. Fishermen's interviews confirm the presence of the species in the southern area also in winter. In contrast, in the north-west, where no fish farms are present, bottlenose dolphins are observed further off-shore, at a distance of about 6 nautical miles from the shore.

This preliminary data further confirm the attractiveness of fish farms for this species, as was observed in other Mediterranean areas. Further investigations are necessary to correlate species occurrence with different ecological features and human interactions, to better understand the species habitat selection around Maltese waters and aid the development of appropriate management strategies.

Counting what we cannot see: Estimating humpback whale availability bias using UAV.

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Estimates of cetacean population size using counting or distance sampling methods require accounting for the proportion of animals that are unavailable to be detected at the time of the survey by surface-based observers. It is especially important for aerial estimates where aircraft speed leads to a short sampling window. To incorporate the so-called availability bias, land-based and more recently telemetry data have been used. From these data, the modelling of time an individual spends over and under sea surface can be used to adjust estimates of abundance. As an alternative to these approaches, we implemented UAV surveys to conduct focal observation of humpback whale groups off the Southwestern Atlantic Ocean during

the 2018 breeding season. Availability bias is estimated using Markov modelling, and the resulting estimate of bias is used to correct abundance estimates from an aerial line transect survey. Preliminary results indicate how important it is to model the same object unit as in the distance sampling survey (i.e., groups or individuals), the financial and analytical advantages of using only UAV data to estimate availability bias for short-dive cetaceans; and the potential of using UAV data to obtain unbiased estimates of group size. The main advantage of using focal follows is that UAVs have similar perspectives to that achieved from aerial surveys. In contrast, telemetry data can only inform us to whether an animal is at surface or not, but is unable to evaluate its availability since animals can be detected even when they are subsurface. This has the potential to underestimate availability bias which leads to overestimation of abundance. We argue that UAVs are a more realistic method to generate data for availability correction compared to the current methods in use.

Investigating the habitat use of coastal bottlenose dolphins (Tursiops truncatus) in response to a major hurricane

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Extreme events provide a unique opportunity to understand how sudden changes in the environment can impact species and ecosystem processes. Hurricanes can cause drastic changes to aquatic ecosystems, with possible short-term changes to salinity, hypoxia, mangrove and seagrass loss, for example. In addition to the immediate changes to the environment, hurricanes leave lasting demographic effects on coastal populations. Studies in the coastal waters of the Gulf of Mexico and the Bahamas have shown that hurricane events caused changes in social structure, demography, and reproductive success of coastal bottlenose dolphins (*Tursiops truncatus*). There are, however, few studies that have investigated how behavior and habitat use might change immediately before and after a storm. In September 2017, Hurricane Irma, a category 4 storm, made landfall in South Florida, USA. Our study site, the Florida Coastal Everglades (FCE), recorded a storm surge of over 10ft at the mouth of the Shark River Estuary. Five CPOD (Chelonia Ltd., Cornwall, U.K.) passive acoustic monitors have been deployed as part of a Long-Term Ecological Research (FCE-LTER) to investigate the habitat use of bottlenose dolphins. CPODS were deployed across the Shark River estuary, from the mouth to upstream brackish waters, and were used to investigate how environmental conditions (pressure levels, wind speed, temperature, salinity, water levels) correlated with detections of dolphins at a fine scale (hourly) throughout the Shark River Estuary. Dolphin detections per minute (DPM) increased up to 4-fold in the upstream locations, starting two days following the hurricane landfall, and continuing up to two weeks. Investigating the immediate effects of hurricanes on habitat use of coastal species may provide insight on the magnitude of disturbance and how that may affect populations.

Translating the science of oceanic blue carbon into policy action to promote marine mammal conservation and climate change mitigation.

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Oceanic blue carbon refers to the natural processes whereby marine vertebrates trap carbon. We have identified nine mechanisms whereby marine vertebrates can store and sequester carbon. Marine mammals spanning all three taxonomic orders are involved in seven of these mechanisms. They include: 1) storing carbon in living and dead bodies; 2) stimulating nutrient flux to surface waters via excretion of waste products and mixing the surface layer, thus spurring phytoplankton growth; and 3) promoting kelp forest and seagrass growth. Recognizing the role of marine mammals in the carbon cycle is a potentially innovative and important strategy for combating climate change yet it has been overlooked in climate change mitigation strategies. If we can recognize the value of marine vertebrate carbon, many existing marine mammal conservation and management policies (e.g., establishment of marine protected areas, bycatch reduction, hunting and whaling regulations) could qualify as climate change mitigation strategies. With the recent passage of two International Whaling Commission resolutions recognizing the value of whales in ocean carbon storage, a global precedent has already been established. We present the latest state of knowledge on the role of marine mammals in oceanic blue carbon, including quantification of carbon storage and sequestration values. We identify knowledge gaps and future research needs. We discuss strategies for translating the science of oceanic blue carbon into national and international policy actions. A concerted effort by the marine mammal science community that includes integration of oceanic blue carbon data collection within current and future research programs, in addition to timely and effective

communication with policy makers and the public, could be pivotal in stimulating climate change mitigation action.

BaitSTR facilitates simultaneous large scale genotyping of STR loci in non-model organisms – a test case in deep-pedigree reconstruction of Indo-Pacific bottlenose dolphins

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Increasingly accessible next-generation sequencing technologies have enabled genome-scale analysis of non-model species. Most studies that use next-generation sequencing focus on single-nucleotide polymorphisms (SNPs). However, for many questions in population genetics, SNPs are an insufficient or inefficient marker choice, particularly when studying short-term population-level events or when species show low genetic variation. Conversely, short-tandem repeats (STR) offer fine-scale resolution of recent demographic events and have a much higher information content per locus. The recently developed 'BaitSTR' approach facilitates the identification, development, and genotyping of thousands of STR loci through target capture and massively parallel sequencing. This method does not require a reference genome and is therefore highly amenable to use in non-model species. BaitSTR offers a data-dense and cost-effective solution to the impracticality of genome-scale analysis in natural populations. However, it has yet to be applied to population-scale data and still requires robust validation of genotype calls. We will evaluate the feasibility and accuracy of this approach through deep-pedigree reconstruction in a natural population of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in Shark Bay (Western Australia). Pedigrees allow robust evaluation of population parameters, assessment of selective events, determination of the genetic basis of traits, and are a strong complement to behaviour data. We will provide genotypic data on 80 *T. aduncus* from a long-term study population with known relationships using a repurposed panel of 2499 STR loci developed with BaitSTR for Australian humpback dolphins (*Sousa sahulensis*). Ultimately, we posit that through pedigree reconstruction and comparison to known pedigrees, we can broadly assess the power and practicality of employing BaitSTR as the genetic tool of choice in non-model population studies

Acoustic communication is cheap in whistling dolphins

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Toothed whales depend on sound for communication and foraging, which makes them potentially vulnerable to increases in anthropogenic noise. Some noise effects may be ameliorated by increases in amplitude or rate of calling, but such acoustic compensation mechanisms may incur energetic costs. Costs of whistling in the bottlenose dolphin (*Tursiops truncatus*) have been reported to be high (20-50% of resting metabolic rate) despite theoretical estimations (0.5-1% of resting metabolic rate). Here we investigated these contrasting claims by testing the hypothesis that whistling is metabolically expensive for bottlenose dolphins. We did this by measuring the change in metabolic rate in voluntarily participating fasted bottlenose dolphins during whistling and silent trials. The experimental protocol consisted of a two-minute baseline period to establish resting metabolic rate, followed by a two-minute static surface apnea, with or without whistling as cued by the trainers, followed by a five-minute resting period to measure recovery costs. Metabolic rate was measured using a custom-made breath-by-breath respirometer, and acoustic output energy was quantified using two calibrated hydrophones in front of the stationed animal. Daily fluctuations in metabolic rate were accounted for by subtracting the baseline metabolic rate from the recovery costs to estimate the cost of apnea with and without whistles relative to resting metabolic rate. A total of 52 sessions containing 1162 whistles were analyzed. We show that whistling added no significant metabolic cost (4.2 ± 6.9%) compared to that accrued during the static surface apnea control (-0.5 ± 5.9%), and these changes were significantly lower than the previously proposed 20% increase in metabolic rate. Thus, we reject the hypothesis that whistling is metabolically costly for bottlenose dolphins and conclude that vocal

adjustments such as the Lombard response to noise are unlikely to represent large energetic costs for communicating toothed whales.

"Measuring Glacial Ice Castles from the Sky" Using drones to quantify glacial ice habitats used by pinnipeds in Alaska

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Harbor seal (*Phoca vitulina*) populations have experienced significant declines which might be related to climate-driven changes to habitat. Approximately 10-15% of harbor seals in Alaska use tidewater glacial ice as substrate for pupping, molting, and resting, but these habitats are disappearing due to warming temperatures. Little is known about the fine-scale characteristics of glacial habitats used by these animals, making it difficult to identify and quantify habitat changes over temporal and spatial scales. The present study 1) evaluates the accuracy of using unmanned aerial systems (drones) to measure fine-scale dimensional characteristics of floating objects 2) evaluates the accuracy of using cameras mounted to electronic gimbal systems to measure fine-scale dimensional characteristics of glacial ice. Height measurements of objects were obtained from images captured from land, water, and air platforms, and statistically compared with the true heights of objects. There were no statistical differences between the true heights of objects placed on land or water surfaces and the calculated heights of these objects from images that were captured from the airborne UAS (χ2range1.8-0.39;n=;df=9;p=0.98), or the UAS placed on either water (χ2range10.8-1.89;n=5;df=9;p=0.98), or land surfaces (χ2=1.41;n=9;p=0.98). There were significant differences ($p<0.00001$;F=46.18) in the mean error ratios of measurements made for different surfaces. Images of objects (n=5) that were placed on land surfaces and captured from an air platform had the least mean error ratio (-0.009±0.01) compared to objects (n=5) placed on water surfaces and captured from the camera placed on a water platform (0.013±0.019) and objects (n=5) placed on a land surface and captured from a land platform (-0.022±0.024). Our study indicates that remote sensing is a highly accurate method to estimate measurements, but the platform type used to capture the images (F-Distribution(1,24)=33.68) as well as the distance between the object and image (F-Distribution(2,24)=11.32) had significant effects on the error ratio.

Can modelling the drift of bycaught dolphin stranded carcasses help identify involved fisheries? An exploratory study.

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Between the 1st of February 2017 and the 31st of March, 793 cetaceans were found stranded along the French Atlantic coasts. 84% of them were common dolphins, and most of them presented evidences of death in fishing gears. The aim of this work is to test an approach that would help to identify the fisheries potentially involved in any given stranding events. To do this we examined how the likely distributions of mortality of bycaught dolphins inferred from carcass drift modelling coincide with fishing effort statistics in the same area at the same dates for different fleets, generated from the Vessel Monitoring System. Using reverse drift modelling, two main mortality areas were identify during these events, and 3 690 common dolphins (IC95% [2 230; 6 900]) were estimated to have died in fishing gears of the Bay of Biscay during February and March 2017. The relationship between origin of stranded bycaught dolphins and fishing effort distribution during the different stranding events was strongly positive for French midwater pair trawlers, Spanish otter bottom trawlers and French Danish seiners. Co-occurrence highlights a risk but does not presume of interaction of fishing effort on common dolphins nor its intensity. Beyond this diversity of gears, two characteristics appeared to be shared: targeting predatory fishes in winter (sea bass and hake) in winter and using high vertical opening gears.

Inferring the distribution of cetacean species in deep waters of Gabon. The potential of seismic prospecting surveys as a source of marine mammals data in data-scarce regions.

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Gabon has recently approved the biggest network of marine protected areas in Central Africa. However, to date there have been no focused surveys of cetaceans outside the coastal zone. This information gap can be filled using data collected by marine mammal observers during seismic surveys in deep waters. Between 2013 and 2017, 13 surveys were conducted in Gabonese deep waters. A first estimation of cetacean distribution has been estimated for the region based on visual sightings and acoustic detections, combined with corresponding effort data. To this end, we assumed the spatial location of cetacean occurrences as a point process to propose a model-based inference using a spatial log-Gaussian Cox process. The method adopts a flexible stochastic partial differential equation (SPDE) approach to model spatial structure in density and Integrated Nested Laplace Approximation (INLA) for Bayesian inference. It allows simultaneous fitting of detection and density models and permits prediction of density at fine scale while specifically accounting for distance sampling and the local-scale dependence structure of the data. This methodology can be used to develop informed management plans and give insights of species distribution in data-scarce regions where offshore seismic surveys are available.

Entanglements Of North Atlantic right whales increase as their distribution shifts in response to climate change: The need for a new management paradigm.

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Since 1980, the leading causes of mortality in North Atlantic right whales (*Eubalaena glacialis*) have been collisions with ships and entanglements in fishing gear, which combined caused an estimated 50% of all detected right whale deaths. In addition, 83% of all right whales display scars or carry ropes indicative of past entanglements in fixed fishing gear. Deaths from vessel strikes have declined as a result of recent legislation to reduce vessel speeds in right whale coastal habitats. However, despite a nearly 20-year effort by the U.S. National Marine Fisheries Service to reduce accidental kills of whales in fishing gear, no improvements in these rates of entanglement have been detected. In the present study, we used the North Atlantic Right Whale Catalog Photo-Identification Database to identify records of serious injury and mortality from entanglement. We found that entanglements increased significantly over a 35-year period, especially in the most recent decade. Since about 2009 the migratory phenology of right whales has changed dramatically. Right whales are no longer aggregating in most of their traditional feeding grounds during the expected times of year. Historic right whale habitats in the Gulf of Maine have warmed at an unprecedented rate. Changes in temperature and circulation have been linked to reductions in *Calanus finmarchicus*, the primary prey of right whales, and declines in residency patterns of right whales. Right whales are responding to a rapidly changing climate in realtime. In contrast, the resource management structure has not adapted to these changes. This phenological mismatch between humans and whales highlights the need for industry-wide blanket protective measures that will reduce or eliminate entanglement altogether. Reduced breaking strength ropes, ropeless fishing, and effort reduction are all options that should be considered throughout their range from Florida to Iceland.

Frequency patterns in humpback whale (Megaptera novaeangliae) song.

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Acoustic signals are a primary mode of communication for species in a variety of terrestrial and aquatic habitats. The need to exchange signals with conspecifics beyond visual proximity is especially important across large territories or home ranges, or for migrating species. Humpback whales produce songs that are highly structured. Despite the wide range of frequencies produced by humpback whale singers, and the fact that signal frequency determines how far sounds propagate underwater, little attention has been given to how singers organize their use of sound frequencies within songs. Based on the distances over which songs travel, we predicted that singing humpback whales consistently produce units with energy

focused in one or more specific frequency bands to maximize transmission efficacy. Songs recorded from 2013-2016 in the Gulf of Tribugá, Colombian Pacific suggest that not only do singers favor specific frequencies, but that they consistently concentrate their sound production within three frequency bands across years. One band spanning frequencies between 250-475 Hz is the most stable and consistently used band. Further analyses revealed that singers often cycle through predictable sequences of frequencies within song sessions. Transition probabilities between frequency bands show that singers commonly switch between medium and low bands, but not between low and high bands. Collectively, these findings suggest that singing humpback whales produce sequences of peak frequencies that are as predictable, and perhaps even more predictable, than the pattern sequences that traditionally have been the main focus of song analysis. Whether singers change their use of frequency bands in response to increased anthropogenic noise, social interactions, or as themes evolve over time, is an important question for future research.

Physiological response of an isolated population of bottlenose dolphins (Tursiops truncatus) to anthropogenic stressors, Bocas del Toro, Panama.

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The Archipelago of Bocas del Toro (BDT), on the Caribbean site of Panama, is the home of a small and genetically isolated population of bottlenose dolphins. In Dolphin Bay, dolphins are regularly exposed to intense dolphin-watching interactions. Previous research has found evidence that intense vessel traffic and its associated noise can generate stress on marine mammals. This is of major concern in coastal areas where dolphin habitat overlaps with various human activities. The objective of this project was to determine if boat traffic increases the concentration of cortisol hormone, a common biomarker of stress in marine mammals, and the reproductive hormones (progesterone and testosterone). These steroid hormones were used to evaluate the possible negative physiological effects to dolphin watching activities. During the last three years we collected 26 remote biopsies samples using a PAXAMRS rifle system during high and low tourist season. Preliminary data shown that mean cortisol concentration of this population tended to be significantly higher (0.52 ng/g $\pm$ 0.31; mean$\pm$SD) during the high tourist season compared with the low season (0.26 ng/g $\pm$ 0.14); t-test $t(13)=2.30$, $p=0.038$, no significance relationship between cortisol and reproductive hormones have been found yet. Understanding the physiological consequences of boat traffic, particularly dolphin watching activities, will significantly contribute to current management and conservation efforts. These efforts may include changing this population IUCN designation from vulnerable to threatened at local level. Ongoing research includes the collection of biopsy samples from a control population of dolphins that is not involved in dolphin-watching activities.

Marked phylogeographic differentiation of sei whale based on mitochondrial DNA analyses from Northern and Southern Hemisphere populations

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The sei whale, Balaenoptera borealis, presents a disjointed geographic distribution, with populations that are separated either by continental landmass, as in the Northern Hemisphere, or by the Intertropical Convergence Zone between hemispheres. Such distribution, together with patterns of seasonal

migration, could result in a strong phylogeographic structure. Significant genetic divergence between sei whale from the North Atlantic and North Pacific Oceans has been reported, however, limited samples from the Southern Hemisphere precluded a global analysis. The largest whale mass mortality event ever recorded for this species occurred in southern Chile, with at least 340 dead rorquals. This has become the largest source of samples for the species in the SH. Here we evaluate the population structure between sei whale populations, comparing the North Pacific n = 18, the North Atlantic n = 86 and the South Pacific (n = 87, including 14 skins and 61 bones from the Chile mass mortality), and the South Atlantic (n = 2). At a local level, mitochondrial DNA control region analyses from South Pacific recovered 33 haplotypes, eighteen of which are shared by two or more individuals. High values of haplotype diversity (h = 0.97) and nucleotide diversity (π = 1.01%) were found. At a global scale, phylogeographic analyses showed a strong genetic differentiation between the Southern Hemisphere and both North Atlantic (FST = 0.69, p = 0.001) and North Pacific (FST = 0.32 p = 0.001), and a possible migration event from South Pacific to North Atlantic. Together with other recent studies, our results point to a marked phylogeographic differentiation between sei whale in the North Pacific, North Atlantic and Southern Hemisphere, which may reflect the existence of three major population units. These results need to be complemented by more samples from other locations within the Southern Hemisphere and the use of nuclear

Whale watching activity as a useful tool to monitorize the population of bottlenose dolphin (Tursiops truncatus) in the Strait of Gibraltar

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The Strait of Gibraltar is a unique habitat where up to seven different cetacean species can be found in the area throughout the entire year or in distinct seasons. These consist in either high level predators taking advantage of the highly productive waters due to the particular oceanographic conditions, or transient migrators moving between the Mediterranean and the North Atlantic. Over the last 20 years, the area has become a hotspot for whale watching activities which, when performed responsibly, can serve as an additional tool for cetacean conservation through established data collection protocols for opportunistic platforms. One of the most sighted resident species in the Strait is the bottlenose dolphin (*Tursiops truncatus*), with an extensive dataset collected during whale watching activities.In this study we have analysed photosale of bottlenose dolphin dorsal fins taken during the period 2011-2018 using photo-ID methods, in order to create a catalogue of the individuals seen during whale watching trips along the Strait of Gibraltar. Our aim is the assessment of social group composition of this species and the identification of any changes in time. Long-term photo-identification studies can provide insight into habitat use, movements, and life history characteristics of individual cetaceans at individual and population levels, adding valuable information for conservation efforts.

Assessment of anthropogenic disturbances due to ecotourism on a grey seal (Halichoerus grypus) colony in the Blasket Islands, SW Ireland.

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Wildlife-oriented tourism has experienced a rapid growth in recent decades. While ecotourism aims to promote conservation, its actual impacts on wildlife and populations must be assessed, especially during critical stages of the life cycle. The grey seal (*Halichoerus grypus*) is a protected species in Ireland and therefore, its population is subject to monitoring programs. Consequences of anthropogenic disturbances due to ecotourism are being assessed on a grey seal colony over pre-breeding, breeding and mating seasons in the Blasket Islands Special Area of Conservation (SAC), SW Ireland. Here, the tourist season overlaps with part of the pupping period, and consequently the most sensitive time in terms of potential disturbances. Disturbance might adversely affect the fitness of this species by reducing resting and nursing times, forcing them into the sea and leading to abandonment of offspring. Impacts of ecotourism are being evaluated by investigating differences in the behaviour of grey seals hauled out on the beach between undisturbed and disturbed conditions due to approaching ferries, powerboats and walking tourists. Response distance of seals to approaching ferries is also taken into account. Preliminary results show a more frequent display of vigilance behavior (mean ± SD = 21.82 ± 11.46% of seals) and less proportion of

resting seals (62.34 ± 13.13%) under disturbed compared to undisturbed conditions (6.26 ± 3.10; 73.70 ± 15.79% of seals vigilant and resting respectively). The results of this study have identified the need for increased conservation efforts as well as a strict code of conduct for boat users in the area to reduce the effect of disturbance.

The one that got away? Evidence of failed predation events between a grey seal (Halichoerus grypus) and a harbour porpoise (Phocoena phocoena).

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The relatively recently observed phenomenon of harbour porpoise (*Phocoena phocoena*) predation by grey seals (*Halichoerus grypus*) has been well documented in Europe over the last few years. These include numerous observer records, photos, videos, as well as multiple porpoise carcasses being recovered around the UK coastline with pathological evidence of grey seal interactions. Evidence obtained from these examinations include characteristic teeth and claw marks and the removal of large areas of blubber. However, as with all predator-prey interactions, the success rate is not 100%. The UK has conducted necropsies on four porpoises that suggest that the initial non-fatal interaction between the two species resulted in a bacterial infection with *Streptococcus phocae*. In all cases investigated the initial route of infection was suspected to be via penetrating cutaneous injuries found on the tail stock. The injuries found were consistent with bite marks from a set of canine teeth, the measurement of which indicated that these had most likely been made by adult male grey seals. The seal bite most likely led to the *S. phocae* infection, subsequent loss of condition and ultimately the death of the porpoises. In 3 out of 4 cases *S. phocae* was isolated from samples of the brain and in the fourth case from the liver. The tale stock lesion (bite wound) of one individual was also found to have severe infectious processes, with a large volume of purulent material present and highly reactive tissue around the puncture wounds. *S. phocae* was isolated directly from this site. The interval between the initial bite and eventual death is unknown, but the generally poor nutritional condition of the animals examined suggests this may have been a prolonged period.

Welfare in the wild: The status and future research needs of UK marine mammals.

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Concerns regarding marine mammal welfare have grown significantly in the last century, often focussing attention on negligent practices by animal performance and aquaria. The welfare of wild marine mammals, however, receives less attention, despite the implications of poor welfare. Welfare in this context can be defined as meeting the environmental and biological needs of a marine mammal, e.g. food supply, habitat, physical health, thus diminished welfare is defined as failing to meet these needs. This can cause a wide range of adverse impacts such as reproductive failures and beaching. Fatal threats to marine mammals, such as whaling, have received significant public support, whereas researching and improving the welfare of marine wildlife through the lens of whether its needs are being met is as an overlooked theme. This is reflected in the lack of consideration of marine welfare in the planning and management of marine spaces.

We have undertaken a review that assesses how welfare has been examined compared to changes in behaviour and physiology in marine mammals. We considered research articles published in the UK from 1990-2016 and scored studies based on their interpretation of welfare. The results of this review indicate that welfare is both misrepresented and underrepresented in the current literature. Welfare is seldom explicitly examined, rather it is assumed or not appropriately investigated. We find there to be a distinct lack of studies examining chronic poor welfare, and identify this a key research need. To better inform management decisions relating to welfare, greater research focus should be given to the chronic implications of not meeting the environmental and biological needs of marine mammals, particularly from emerging and geographically underrepresented threats. Proportionate mitigation should be adopted by decision-makers using a precautionary approach where evidence is lacking

Temporal trend of intestinal ulcers in the Baltic grey seal (1977-2016).

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The Baltic grey seal *(Halichoerus grypus*) can be heavily infected by acanthocephalan parasites (*Corynosoma sp*) in the ileocaeco-colonic region and ulcers are often seen in the area at necropsy. To investigate temporal and spatial trends of these lesions, intestines from 2172 seals from 1977-2016 were examined.

The erosions and ulcers in the intestinal mucosa were evaluated on a 4 degree scale: < 4 mm erosions (0), 4-10 mm erosions (1), > 10 mm erosions or ulcers (2) and > 10 mm ulcers also affecting the muscular layer (3). Lesions of moderate (2) and severe (3) degree were considered to be pathological (and referred to as ulcers). The number of acanthocephalan parasites in colon was not counted as there can be thousands of them, but evaluated as no (0), slight (1), moderate (2) or severe (3). Generalized models assuming a binomial error structure were applied to test of the influence of age, year, area and parasites on the occurrence of ulcers.

An increase in prevalence of ulcers was observed in the early 1980s and up to mid/late 1990s, followed by a decrease until 2016. The overall frequency of ulcers was 43% in the Bothnian Sea, 38% in the Bothnian Sea and 23% in the Baltic Proper. Since about 2000 the temporal trend in the three areas have been similar (decreasing from about 50% to 20%).

Perforation of the colonic wall was the cause of death in 26 of the investigated Baltic grey seals. One of them was less than one year old and the others were 1-37 years old. As far as we know, only one case of intestinal ulcer in grey seals has been reported outside the Baltic Sea (Baker, 1980), so this adverse health situation seems unique to grey seals in the Baltic Sea.

Should I stay or should I go? Grey seal pups disperse widely in the southern North Sea.

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Grey seal numbers in the southern North Sea have been increasing over the last 50 years, and thus their role in the ecosystem has become more and more important. However, little is known about their spatial utilisation of the southern North Sea, especially in relation to the dispersal of grey seal pups after weaning. We investigated these little-known aspects by recording the movements of 11 grey seal pups born at the largest German colony (Helgoland) between 2015 and 2017 for between one and nine months after leaving the colony. The individuals moved widely throughout the southern North Sea, some individuals moved long distances, along the Danish coast or to Dutch and UK waters. Based on a point process modelling approach we were able to show that pups strongly increased their distance to Helgoland already in the first weeks and also generally during the first 70 days at sea. We furthermore found that the foraging behaviour increased in frequency until week four which indicates that grey seal pups increasingly used their environment for foraging during these weeks after weaning. Our findings reflect the transition from naïve to more experienced pups which gradually increase their foraging effort and range to cover their increasing energy demand for survival and growth. This study contributes to our knowledge of the spatial utilisation of the southern North Sea by an increasingly important top predator, its behaviour as well as changes of these aspects with increasing age of the pups.

Feeding at depth: Insights into the feeding habits of an opportunistic delphinid revealed by stable isotope analysis.

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As apex predators extensively influence of their environment, knowledge about their feeding strategies and trophic ecology is crucial for ecosystem management. Although short-beaked common dolphins (*Delphinus delphis*) are widely distributed and abundant, we know very little about their foraging ecology except for limited stomach content studies. Generally perceived as opportunistic predators that feed locally on abundant small pelagic schooling fish, common dolphins are frequently bycaught in related fisheries. Obtaining direct observations of feeding

habits of oceanic species is challenging. However, stable isotope analysis can provide useful insights into recently ingested and assimilated prey. This information can then be used to evaluate the short-beaked common dolphin's potential exposure to commercial fisheries bycatch.

We investigated the effect of age, sex, and season on the diet of short-beaked common dolphins in the Hauraki Gulf, New Zealand, using stable isotope analyses of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) on skin samples from stranded animals between 2004 and 2016. Tissue samples of potential prey species (previously identified from stomach content analyses) were sampled in 2018. Isotopic values of dolphin and prey tissues were then processed using MixSIAR models to determine the relative proportions of different prey assimilated.

Juvenile had higher $\delta^{15}N$ values than adults, suggesting ontogenetic dietary changes. Nitrogen isotope values were higher in austral autumn/winter compared to spring/summer, whilst $\delta^{13}C$ values decreased throughout the study period, suggesting temporal changes in primary productivity. Sex had only a minor effect on $\delta^{13}C$ values, with males and females isotopic niches overlapping by 55%. MixSIAR modelling revealed that 84.1% of the dolphins' diet consisted of species predominantly occurring in deep waters. These results highlight the importance of deep-water prey for Hauraki Gulf short-beaked common dolphins. This is surprising given the time they spend foraging in shallow waters of the gulf. Foraging in deeper offshore waters increases their susceptibility to fishery interactions and may explain current bycatch concerns for this population.

Mass stranding and unusual sightings of northern bottlenose whales (Hyperoodon ampullatus) in Skjálfandi Bay, Iceland

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Beaked whales, such as the northern bottlenose whale (*Hyperoodon ampullatus*) are odontocetes characterised by their extreme, deep-diving behaviour and are therefore rarely seen in coastal and shallow waters. During summer and autumn 2018, unusually high numbers of northern bottlenose whale sightings, in addition to strandings of multiple beaked whale species, were reported around the coast of Iceland. These events coincided in time with the beaked whale Unusual Mortality Event (UME) around the British Isles. To determine the principal drivers behind these events, it is essential to collate the available information. Here, we describe a series of unusual sightings and strandings of northern bottlenose whales in Skjálfandi Bay, Iceland, between July and October 2018. We used opportunistic platforms, specifically whale-watching vessels and land-based observations, to record sightings and to collect photographs and behavioural data. Twenty-four individuals were identified through photographic analysis. Within the whole period, we observed a drastic change in the behaviour, diving patterns and sightings distribution of animals, together with a decrease in body condition and severe skin lesions. At least six individuals died in the bay during four separate events. A first adult female live stranded a month after the first sighting, soon followed by the live mass stranding of three sub-adult females. Finally, a dead stranded juvenile of unknown sex was found, as well as an adult female floating in the bay. To our knowledge, this is the first description of such extreme events for northern bottlenose whales. These findings will add to our current knowledge of the species and hopefully contribute to determining the drivers behind the UME of beaked whales across the North-east Atlantic during summer and autumn 2018.

The North Atlantic right whale consortium: A model for advancing science and conservation of marine mammals.

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Research collaborations on all aspects of a species' biology throughout its geographic range are critical for effective marine mammal conservation. Challenges to such collaborations include sharing data and developing standardized data-collection protocols and frameworks to manage access to the data. The North Atlantic Right Whale Consortium (NARWC), formed in 1986 by five organizations independently studying the endangered North Atlantic right whale along the east coasts of the United States and Canada, is an example of a collaboration that successfully met these challenges. The NARWC's goal to coordinate research efforts and protocols and share data among these founding organizations facilitated a broader understanding of North Atlantic right whale biology and conservation needs, including critical information on distribution, reproduction, mortality, and anthropogenic impacts. Expanding on this success, the NARWC developed an open membership model that now includes research and conservation organizations, industry stakeholders, and municipal, state, and federal agencies in both the United States and Canada. Committed to the open exchange of information, the NARWC oversees multiple right whale databases, submissions to which are voluntary yet comprehensive. The NARWC database frameworks include well-defined QA/QC protocols, open access for management data requests, and peer review of access requests for research and publications. These approaches have resulted in many collaborations, multi-group publications, and a broad community understanding of detailed aspects of North Atlantic right whale biology. An annual meeting, a public website (narwc.org), and an annual "report card" are used to disseminate the latest information on right whale science and conservation progress and needs. The NARWC has served as the cornerstone for right whale research and conservation since its inception and its data sharing and collaborative framework is unparalleled in the marine mammal arena. Such an approach serves as a model for establishing other species related consortia, particularly for threatened and endangered populations.

Data deficient! A review of zoo record-keeping for captive bottlenose dolphins in Germany.

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Data was obtained from the husbandry and veterinary records of 25 common bottlenose dolphins (*Tursiops truncatus*) held at the Tiergarten Nűrnberg (TgN) in Nuremberg, Germany between the years 1989 - 1991 and 2000 – 2014.

A systematic review of the data revealed that the records were neither standardized nor regularly recorded. Therefore, it was impossible to evaluate the behaviour and health of the dolphins in a scientific way.

A number of different drugs were administered to the dolphins, with Diazepam the most commonly administered. Aggressive behaviour and injury to both dolphins and staff were also recorded , as was calf mortality and the transfer of dolphins between facilities.

Under the requirements of the EU's Zoo Directive, EU member states must ensure all zoos implement a number of conservation measures, including "keeping of up-to-date records of the zoo's collection appropriate to the species recorded". This requirement is also mirrored in legislation implementing the Zoos Directive in Germany.

Open source, autonomous, camera system to facilitate the monitoring of Mediterranean monk seal caves

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Mediterranean monk seal *Monachus monachus* is the rarest seal species in the world and it is classified by IUCN conservation as Endangered. An Open Source, autonomous and connected time-lapse camera monitoring system was designed, assembled and installed in the Greek Ionian islands between May-November in 2018 and 2019 to test its feasibility as a possible affordable tool to assess the site-fidelity and distribution of the species. The first two prototypes were assembled using standard but sturdy electronic components in an attempt to keep the total price low (< 2000€) while being able to monitor simultaneously outside and inside a remote and partially flooded coastal cave, where monk seals rest and reproduce. Preliminary tests in 2018, monitoring two different caves found on the Northern tip of Kefalonia Island resulted in monk seals being recorded on two occasions and provided regular monitoring of human activity (e.g., boats, kayaks and divers) in the vicinities of the caves. Technically, both deployed systems

proved to be autonomous using solar energy from beginning of June to mid November, successfully recording pictures 85% and 92% of the time respectively. Cameras were set to trigger images every 15 minutes during day and night. These images were recorded locally on a USB key and remotely sent to a server in Switzerland using a 3G/4G router. This way researchers could not only have access to the generated data from anywhere, anytime (e.g., on their tablets or smartphones) but, most importantly, it provided immediate back up of the data stored locally in case it got accidentally damaged or even stolen. A third system will be installed on an inlet in the Inner Ionian Sea Archipelago, where monk seals are regularly observed and regular visits by tourists (i.e., disturbance) pose an important threat.

Microplastics in marine top predators - A pilot study from German waters.

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Plastics build a high share of marine debris pollution in our oceans. Next to large debris objects detectable by the naked eye, the fractions beyond visible detection came into focus of modern research in recent years. The so-called microplastic particles (MPPs) operate as accumulators and circulators of toxins, chemicals, bacteria and viruses. Especially, marine mammals as top predators are susceptible of accumulating both. Besides, the physical impacts of MPPs are widely unknown. Before the impacts and effects of MPPs can be fully understood, the presence and extent within the gastrointestinal tract (GIT) have to be assessed. Therefore, the occurrence, amount and composition of MPPs in top predator species need to be investigated.

GIT samples of stranded marine mammals found on the coasts of Schleswig-Holstein (Germany) were collected during regularly conducted necropsies since 2014. The target species are the regularly occuring top predators in German waters: harbour porpoise [*Phocoena phocoena*], harbour seal [*Phoca vitulina*] and grey seal [*Halichoerus grypus*]. We investigate 10 stomachs, 60 intestine samples, and 30 faeces samples collected on a sandbank, to assess the occurrence of MPPs in the GIT of the target species since 2014.

Furthermore, the already established method by Bravo Rebolledo (2013) was improved and the utilisation decreased secondary pollution and conservable loss. Moreover, the found MPPs were successfully identified by Nile Red staining using a fluorescence microscope and were verified, a by Raman spectroscopic analysis for polymer identification.

With those valuable data collection, we were able to analyse the occurrence of MPPs in the GIT of marine mammals from German waters for the very first time.

The investigation on marine debris occurrence of all sizes and its impacts on marine biota and habitats are essential for implementing the European Marine Strategy Framework Directive (MSFD).

The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, Phocoena phocoena, using standings data from 1992-2012.

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Post-mortem examinations of harbour porpoises, *Phocoena phocoena*, regularly reveal heavy parasitic worm burdens. These same post-mortem records show varying levels of polychlorinated biphenyls (PCBs) accumulating in the blubber of porpoises. Using a data set comprising harbour porpoises stranded in the UK between 1989 and 2002, previous research has shown a positive relationship between parasitic worm burdens and PCB accumulation in harbor porpoises. However, overall levels of PCBs declined sharply during that period and may be below proposed concentration thresholds for negative health effects. Here, we ask the question whether the relationship between parasitic worm burden and PCB accumulation still exists, using data gathered between 2002-2012. Overall, we find that there is still a positive relationship but this is more pronounced in parasite burdens recovered from the cardiac stomach than bronchi or pulmonary arteries. Suppression of the immune

system is the proposed mechanism for increased parasite susceptibility and our findings suggest that the legacy of PCB pollution continues to have adverse effects on harbor porpoise health in UK waters.

Studying the effects of ocean properties on the diving ecology of Weddell seals using hidden Markov models.
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Weddell seals are a resident Antarctic species occurring on the fringe of the continent and are highly adapted to living in the sea ice year-round - a highly seasonal, highly dynamic environment. The Weddell Sea is unique compared with other parts of the Antarctic where Weddell seals occur. It has a wide continental shelf and is an important area for understanding how climate affects ocean circulation via dense seawater formation. There are early signs that Weddell Sea physical ocean dynamics are changing, making it important to characterise the relationship between seal behaviour and ocean properties in this area. To improve our understanding of longer term (e.g. weekly, monthly or seasonal) relationships between diving behaviour, oceanographic variables and bathymetric features, we model dive variables as time series, including haulout and surface behaviour to consider a more complete behavioural time series. We use a multivariate hidden Markov model (HMM) to estimate behavioural states along the time series of behaviour recorded for individual seals. Maximum dive depth, duration, and hunting time are used as state variables in the HMM. We specify haulout and surface behaviour as known states in the model, while estimating the parameters of the state variable distributions for four dive states. We use data collected from 19 adult seals tagged in the Weddell Sea in the austral summer of 2011. We use both classical and hierarchical HMMs to analyse tracking data collected using animal-borne sensors and compare the inferences. Our results suggest that seals spend more time hunting during deeper, longer dives. We show that these deep dives are associated with the seasonal inflow of modified Warm Deep Water onto the continental shelf in the southeastern Weddell Sea.

Distribution, density, and habitat use of harbor porpoises, Phocoena phocoena, in Frenchman Bay, Maine in relation to cruise ship presence
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Bar Harbor, Maine is a popular cruise ship destination for several months of every year. In the last three years, the number of cruise ship visits to Bar Harbor has dramatically increased. Little is known about the effect of cruise ship presence on harbor porpoise distribution or density in general let alone in the Gulf of Maine. Although the primary threats to harbor porpoise are gill nets and entanglement, cruise ship noise pollution and presence may impact nearby harbor porpoise presence similarly to noise pollution from acoustic harassment devices or offshore wind turbine construction and operation in European waters. Six C-PODs (Chelonia Limited) were moored in Frenchman Bay at fixed depths but varied distances from cruise ship anchorages in the harbor. Acoustic data were collected from June to November in 2018. The variables interclick interval, clicks per second, and detection positive minutes were analyzed by cruise ship presence and absence. Interclick interval is significantly higher during cruise ship absence than presence. Clicks per second are significantly higher when cruise ships are present. Finally, harbor porpoise detection positive minutes decrease significantly in the presence of cruise ships. Data collection will continue for those months in 2019.

UAV derived photogrammetric assessment of Mediterranean monk seal Monachus monachus body-length and condition
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Measurements of body-size and mass can be used to understand several ecological and life-history traits of a species and are key towards the assessment of an organism's body condition, a proxy for its ecological fitness. We obtained body-length measurements and assessed body condition of Mediterranean monk seals *Monachus monachus* observed in the Inner Ionian Sea (Greece). Given the species' reclusive habits, direct manual morphometric information is difficult to gather. We obtained nadiral photographs using an unmanned aerial vehicle (UAV) and applied a photogrammetric approach to obtain standard body-length and width details. These were subsequently used to derive an index for body condition (BCI). UAV onboard camera and altitude sensors were previously calibrated to obtain a regression equation relating flight elevation and pixel distances measured on photographs. High-resolution images were extracted from videos

recorded during each flight and linked to flight data. During three flights, over 64 minutes of video were recorded and 311 images were extracted and later used for photogrammetric analyses. Average derived seal standard body-length and BCI were 148.8 cm (range= 103.1-189.6 cm) and 4.6 (range= 3.6-5.7), respectively. While repetitive measurements were obtained for each same individual seal, no interannual recaptures were obtained preventing the evaluation of annual growth and changes in BCI. This study is the first to apply UAV technology and photogrammetry methods to assess body-length and condition in Mediterranean monk seals. Although preliminary, our results show that this non-invasive approach provides a valuable tool to monitor this reclusive species. Using simple metrics such as body-length and condition, the influence of a variety of environmental and physiological factors can be evaluated. In this context, our results therefore pose the basis for further research with the potential to provide pivotal information to inform management and conservation of an Endangered charismatic species.

Patterns and trends in cetacean occurrence revealed by Shorewatch, a land-based citizen science programme in Scotland (UK)

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Shorewatch is a citizen science project, organized by Whale and Dolphin Conservation, that records the occurrence of cetaceans during regular standardised watches (duration 10 minutes, spaced at least 1 hour apart) from a series of locations along the coast of Scotland (UK). Observer training and a clearly define protocol help deliver a valuable source of information about cetacean occurrence and activity along the coast. Since 2005, over 52000 watches have generated over 11000 sightings of at least 18 cetacean species, In addition to species, time and location of sightings, observers record group size, presence of calves, and sea state. Statistical models of sightings rate for the most commonly sighted species (bottlenose dolphin, harbour porpoise and minke whale) demonstrate seasonal, geographical and year-to-year differences in occurrence. Thus, bottlenose dolphin sightings show a clear seasonal cycle, highest in May and lowest in November. Harbour porpoise sightings declined from 2013 to 2014 but increased again until 2016. Minke whale sightings increased steadily from 2012 to 2017, peaking in May to July. While the bottlenose dolphin sightings rate was highest in Spey Bay (near Elgin in the Moray Firth), harbour porpoise and minke whale were most frequently sighted at Tiumpan Head (Isle of Lewis). The power to detect declines in local abundance (sightings rate) over a 6-year period (following European legislation) depends on the underlying sightings rate, the number of watches and the rate of decline. Based on the highest sightings rate (for bottlenose dolphins at Spey Bay in June) and assuming a binomial distribution of sightings per watch, around 500 watches (each year) are needed for an 80% likelihood of detection of a 10% per year annual decrease. Ongoing review and analysis of data from this successful citizen science programme will identify best practice and ensure usefulness to scientists and policy-makers.

Guiana dolphins increase group cohesion after playbacks of bottlenose dolphin sounds

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Two cetacean species, Guiana dolphins (*Sotalia guianensis*) and bottlenose dolphins (*Tursiops truncatus gephyreus*) co-occur in a coastal area in southern Brazil, with an apparent habitat partition. This segregation can be motivated by ecological factors, such as habitat preference and competition. However, a local record of an agonistic interaction between these species suggests that Guiana dolphins might avoid bottlenose dolphins due to risk of aggression. In this work, we tested whether Guiana dolphin responds to the sounds of bottlenose dolphin through a controlled playback experiment. We used aerial images from a drone to detect surface behavior changes in Guiana dolphins by comparing periods before, during and after the exposure. Four exposure sessions were performed, with six minutes of videos per session, two minutes for each period/treatment. From these video footages, we extracted 281 frames with dolphins visible in the surface. Aerial videos were recorded

at standard altitude (~50 meters), and we use the number of individuals in each extracted frame as a proxy for group cohesion. Thus, our group cohesion proxy was used as response variable in a generalized linear mixed model (GLMM) to test if the response varied in function of period/treatment of the experiment and the number of previous exposures to playbacks during the day (from 0 to 2). We found that during and after the exposure, the Guiana dolphins group tended to be more cohesive. In addition, we found that there is a sensitization, as cohesion was higher whenever there were previous exposures to the playbacks in the same day. Although this is a preliminary result, this tendency of Guiana dolphins to be closer to each other seems to be a response to the presence of an imminent risk of aggression. Thus, fear of aggression appears to shape group behavior of Guiana dolphins in this population.

Diet ecology assessment of cetaceans and Mediterranean monk seals stranded between 2017 and 2019 on Samos Island, Eastern Aegean Sea, Greece.

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An assessment of the digestive system content was performed for 19 dolphins (*S. coeruleoalba*, *T. truncatus* and *D. delphis*) and 5 *M. monachus* found stranded along the shores of Samos Island, Eastern Aegean Sea, Greece. According to the condition code of the carcasses, a complete or partial assessment of the digestive system content and morphometric measurements were performed. Prey and other items, such as marine litter, were isolated and categorised, a taxonomic classification was performed and conserved when possible. Percentage by number (%N), percentage frequency of occurrence (%FO), percentage by weight (%W) and Index of Relative Importance (IRI) were used to investigate the occurrence and relative importance of the prey. Despite some stomachs being found empty, the results of the study show a pelagic and demersal prey species composition for both cetaceans and *M. monachus*, indicating surface and benthic feeding habits. The local dietary assessment needs improved tools and efforts to investigate the distribution range and the role of these species within the marine environment, including the interaction with important ecosystem services such as fisheries. Further molecular analyses, diet-habitat associations, prey selection and foraging mechanisms studies are required on stranded and alive individuals to fully understand their ecology in the study area. Such research is crucial to empower efficient conservation strategies especially for those species like *M. monachus* and *D. delphis* which are facing a drastic decline caused by anthropogenic impacts.

Ultrasonographic blubber thickness changes and body condition determination during rehabilitation in harbor seal (Phoca vitulina) pups.

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Pinnipeds, as most marine mammals, possess a specialized fat layer in the subcutaneous tissue called blubber that supports multiple functions (thermoregulation, reproduction, and buoyancy). The thickness of this fat layer is frequently used as an indicator of body condition, nutritional status, and health. In the current study, 34 harbor seal (*Phoca vitulina*) pups that were admitted for rehabilitation at the Sealcentre Pieterburen in June 2018, were subjected to ultrasonographical (US) investigations. A portable ultrasound scanner with a 3.5/5 MHz convex probe was placed in the pectoral region over the xiphoid process to assess the blubber thickness. The ultrasound image was comprised of fur, skin, subcutis, which contains the blubber, musculature, and thoracic cavity. The echogenicity of these anatomical structures increased with animal growth and its visualization was, therefore, better as the animals grew. The combined skin and blubber thickness were measured at arrival and repeatedly during the rehabilitation process. Later, they were correlated to several morphometric parameters (weight, length, and axillary girth); which showed a positive correlation between blubber thickness variation and all the morphological parameters, most significantly with the animal's weight (R2 = 0.8208). One of the aims of the project was to

assess if ultrasound was a reliable tool to measure blubber thickness; and it was demonstrated that the technique was useful, as the ultrasound measurements were consistent with manually-taken measurements performed during post-mortem examinations. Finally, ultrasonography-based body condition scoring (BCS) was compared with standard BCS classification (nine-point scale). Some differences were found between the two BCS systems; in particular the categorization of seal pups with BCS ranging from three to five was more challenging compared to the categorization at the extreme classes. In conclusion, ultrasonography has been proven to be an objective and useful instrument to assess the body condition of harbor seal pups admitted for rehabilitation.

Environmental DNA effective for cetacean research in all regions? A case study of seawater sampling in the presence of killer whales (Orcinus orca) in the Northeast Atlantic.

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Whilst environmental DNA (eDNA) is becoming increasingly established in biodiversity monitoring of freshwater ecosystems, the use of eDNA surveys in the marine environment is still in its infancy. Here, targeted quantitative PCR (qPCR) and Whole Genome Enrichment Capture followed by shotgun sequencing was used in an effort to amplify killer whale DNA in seawater samples collected in close proximity to killer whales off south Iceland and from pelagic fishing vessels targeting Atlantic mackerel (*Scomber scombrus*) in Scottish and Irish waters. Samples were collected both inshore and offshore, in varying sea conditions and from the surface and subsurface but none returned strongly positive detections of killer whale DNA. Laboratory methodologies were validated by successfully amplifying a dilution series of a positive control of DNA extracted from killer whale blood from a captive individual. Furthermore, Atlantic mackerel DNA was successfully amplified from the same seawater samples. Positive eDNA detections of mackerel, which was present at all sites during sampling, were found for almost all samples. The various eDNA collection and amplification methodologies used are discussed, along with the abiotic and biotic factors that influence eDNA detection. Possible explanations for the lack of killer whale positive detections are provided along with consideration for potential pitfalls and the apparent limitations of eDNA for genetic research on cetaceans, particularly in offshore regions.

Mercury speciation and stable isotopic composition in marine mammals: New insights and perspectives.

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Mercury (Hg) is a persistent toxic compound whose amount in the global biosphere has at least tripled since industrialization. Recently, the study of the seven Hg stable isotopes has emerged as a new promising technique affording to explore the Hg cycle both in situ and in laboratory. Mercury stable isotopes display both mass dependent fractionation (MDF, reported as δ^{202}Hg) and mass independent fractionation (MIF, reported as Δ^{199}Hg and Δ^{201}Hg). Our recent findings about Hg accumulation in the European seabass, *Dicentrarchus labrax*, showed how the combination of Hg isotopic values with Hg speciation allow tracing back Hg environmental sources as well as metabolic pathways within the organisms. However, such interpretation gets more complicated in more physiologically complex animals such as seals. With the aim of study basal Hg kinetic in an top predator without the influence of distribution and diet specialization, we measured T-Hg levels, speciation and isotopic composition in 6 captive pups of hooded seals, *Cystophora cristata,* and their diet the Norwegian herring *Clupea harengus*. The main objective was to select the tissue in which the information about Hg pathways would be conserved, leading to the optimal tracing of Hg sources along the food web. MMHg ranged between 84 to 98% in hair, 74 to

95% in muscle, 7 to 38% in liver and 4 to 27% in kidney. A significant ^{202}Hg enrichment resulted between seal hair and herring ($p = 0.011$), indicating important MDF between the ingested prey and these tissues. Instead, a significant MIF (Δ^{199}Hg and Δ^{201} values) was observed only between seals' kidney and herring ($p = 0.0003$). Our results showed that hair represents the best tissue for the analysis of Hg biomagnification along food webs; and that with the exception of kidney, MIF signal is conserved in all tissues during assimilation of prey items.

Monitoring marine mammals and floating marine litter in the Western Mediterranean's transect: The new Barcelona-Tangier trans-boundary transect.

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The Mediterranean Sea is one of the most polluted seas in the world but at the same time it hosts a number of threatened species, including sea turtles and cetaceans. Several monitoring programs are active across the basin to estimate abundance, distribution and trends of these populations. On a long term basis, the Fixed Line Transect (FLT) Mediterranean network joints international research organizations (*e.g*. universities, NGOs) to systematically monitor using passengers ferries the presence of marine mega-fauna (*i.e*. cetaceans, sea turtles, seabirds) and its threats, specifically marine litter. We here present the results obtained from the new trans-boundary fixed transect implemented since November 2018 in the Western Mediterranean Sea along the route Barcelona-Tangier. This new transect, made possible through the collaboration with the Grimaldi Lines Company, covers approximately 1200 nautical miles from Barcelona (Spain) to Tangier (Morocco) and back. The whole transect is completed in 4 days and, thanks to the departure times from the two harbours, the portions of transect covered in daylight during the onward and the return routes are complementary. During each transect, one dedicated observer monitors marine mega-fauna from each side of the ferry, using the distance sampling method. A further observer monitors marine macro-litter using the strip-transect method according to the standardised protocol defined by the MEDSEALITTER project. A fourth volunteer records the information collected by the observers. Data obtained from this monitoring transect will fill the gap of information available on the presence of marine mega-fauna in this scarcely studied area. The route will also cover on a long-term basis the recently designed "Corredor de migración de cetáceos del Mediterráneo" protected area. Furthermore, data on marine litter would provide baseline information for future assessment of this threat in the area as well as the information necessary to plan prevention, mitigation and conservation measures.

Conservation status of the Mediterranean monk seal Monachus monachus population at Madeira archipelago

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The small Mediterranean monk seal population of Madeira has been protected since 1988, when only 6-8 individuals were estimated to survive at uninhabited Desertas Islands. The conservation measures undertaken then resulted in a population growth and in an enlargement of the distribution area towards Madeira island. The overall current conservation status of this population was evaluated, based on a study developed from 2012 to 2018, using phototrap cameras to monitor the caves used by seals, GPS tracking to identify foraging areas, observers on board fishing and whale watching boats and a monk seal information network. In 2018, the population size is of 20 individuals older than 1 year, showing a slight recovery trend. Its recovery is limited by a low survival rate during the first year of age (0.38), and a low mean annual reproductive rate (0.51). The high first year mortality is related to breeding in marine caves, limited feeding resources and interactions with illegal fishing traps. The foraging habitat has been identified to be restricted to very coastal waters up to 200 m depth, and the poor conservation status of the marine environment in this area supports the idea of limitation of food resources as one of the main concerns for this population. A differential adult mortality by gender due to direct persecution is also suggested, since although sex-ratio at birth is 1:1, adult females are 3,3 times adult males. All the caves used by the

seals for hauling out and breeding are located inside protected areas.

With this new information, the conservation program that is being conducted in Madeira needs to be re-oriented and an updated Action Plan for the Conservation of the monk seal in Madeira is being developed to minimize detected threats and ensure the long-term survival of this population.

Modelling the functional link between movement, feeding activity and condition in a marine predator.

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The ability to quantify animals' feeding activity and the resulting changes in their body condition as they move in the environment is fundamental to our understanding of a population's ecology. We use satellite tracking data from northern elephant seals (*Mirounga angustirostris*), paired with simultaneous diving information, to develop a Bayesian state-space model that concurrently estimates an individual's location, feeding activity, and changes in condition. The model identifies important foraging areas and times, the relative amount of feeding occurring therein and thus the different behavioral strategies in which the seals engage. The fitness implications of these strategies can be assessed by looking at the resulting variation in individuals' condition, which in turn affects the condition and survival of their offspring. Therefore, our results shed light on the processes affecting an individual's decision-making as it moves and feeds in the environment. In addition, we demonstrate how the model can be used to simulate realistic patterns of disturbance at different stages of the trip, and how the predicted accumulation of lipid reserves varies as a consequence. Particularly, disturbing an animal in periods of high feeding activity or shortly after leaving the colony was predicted to have the potential to lead to starvation. In contrast, an individual could compensate even for very severe disturbance if such disturbance occurred outside the main foraging grounds. Our modelling approach is applicable to marine mammal species that perform drift dives, and can be extended to other species where an individual's buoyancy can be inferred from its diving behavior.

Morphological plasticity of the respiratory system in cetaceans: Advances and its correlates to physiology.

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Despite extensive research on the morphology of the cetacean respiratory system (reviewed in Piscitelli et al., 2013), there is still considerable mystery of how this system has mechanically adapted to a strictly aquatic environment and to withstand both rapid and extreme pressure changes associated with ventilation and diving. In this study, we shed light on new structural variations of the cetacean respiratory system that have direct mechanical and physiological consequences and give morphological evidence for ideas where there were only hypotheses before. We summarize detailed morphological adaptations across six families of cetaceans. This study revealed that all cetacean lungs have a monopodial branching pattern with morphometrics that create an overall low resistance to airflow. In addition, all species had discontinuous spiralling cartilage that extends through the terminal airways to the level of the alveolar duct, a smooth muscle/elastin network that creates sphincters in the terminal airways, and a double capillary network with one on each side of the alveolar septum. Cetacean lungs are exposed to changes in pressure both during breathing and during diving, and thus lungs of species that fill different ecological niches vary in degree of enhancement of these anatomical adaptations in order to meet the demands of that environment. For example, results showed that the terminal airway sphincters of the shallower diving, faster-ventilating species possessed a 2-fold decrease in elastin and collagen, a 2-fold increase of smooth

muscle and were 3.2-fold larger (more robust) with an 8-fold increase in abundance and more regular distribution compared to the deeper diving, slower-ventilating species. Based on morphology observed, the cetacean respiratory system can be classified into three general types of breathing-diving strategies with each strategy optimized for specific mechanics, physiology, and phylogenetic history.

Monitoring a critical population of the Bolivian river dolphin (Inia boliviensis) before and after closing the floodgates of a hydroelectric dam in the Amazon Basin, Brazil: A sample design issue.

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Dam construction threatens aquatic fauna, degrading their habitat and causing population fragmentation. In this context, environmental impact studies were carried out from March 2010 to July 2015 as part of the licensing process concerning the Jirau Hydroelectric Dam construction, located on the Madeira River, Brazil, aiming to assess its impacts on the local fauna. The dam closed its gates in December 2012, creating a ~303 km^2 reservoir. *Inia boliviensis* presents a restricted distribution in Northern Bolivian and Brazilian rivers, which may be aggravated by dam interference. This study aimed to assess the presence of *I. boliviensis* before (BDC) and after dam construction (ADC), also evaluating if the sample design for this assessment was appropriate. Active dolphin searches were performed applying linear transects along the four sections of the river: Abunã, Mutum, Caiçara and Canteiro. About 986 hours of total effort were carried out during 40 days along 250 km of the river in falling, low, rising and high water levels. A total of 24 sightings were recorded BDC in the direct dam influence area (N = 49), while 42 sightings were documented ADC (N = 120). Abunã presented the highest number of records during both periods (BDC: N = 37; ADC: N = 107). A higher number of dolphins was detected during the falling and low seasons (BDC: N = 44; ADC: N = 92). This is expected, due to water level decreases and the highest concentration of dolphins in areas presenting higher food availability. An adequate statistical analysis was not possible, due to the unsatisfactory sample design and non-standardized data collection by different research groups. Implementing a standardized methodology, alongside experienced specialists during the entire survey period, is essential to provide adequate estimates for the monitoring of this population, assuring the best survival conditions for these dolphins.

Effects of coastal development on Indo-Pacific humpback dolphin habitat use in Hong Kong.

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Hong Kong is one of the most densely urbanized coastal communities in the world, where ongoing development activities are a potential threat to Indo-Pacific humpback dolphins (*Sousa chinensis*). Several large-scale development projects in the waters north of and adjacent to Lantau Island, Hong Kong, contribute to anthropogenic noise and vessel activity in near-shore waters, with unknown consequences to dolphins. Although dolphins appear to be somewhat resilient to habitat alterations, abundance has significantly declined in the waters around Lantau Island over the past decade. We examined shifts in animal behavioral activity states and spatio-temporal presence near marine construction projects north of Lantau Island. Land-based observations and theodolite tracking were conducted discontinuously between 2012 and 2016 from seven locations historically used by dolphins. A total of 636 groups of dolphins were recorded totaling 151 hours of tracks. Data on eight proximate marine construction projects underway during sampling periods were obtained from the Government of the Hong Kong Special Administrative Region. Zero-inflated negative binomial hurdle models were plausible, indicating that season, time of day, and construction activity were important factors for predicting presence/absence of dolphins. Dolphin track duration was significantly lower during the spring and significantly lower in areas within 5km of chronic construction activity (θ=1.19, $p<0.001$). Dolphin presence off two locations that were relatively high in previous years, dropped to zero in 2016, concurrent with an increase in the number of nearby construction projects. Long term impacts of habitat displacement may depend on the duration of the disturbance, the quality and proximity of alternate available habitat, and the potential for historically used habitat to recover. One important management tool is designation and effective enforcement of suitable Marine Protected Areas (MPAs), particularly where site fidelity has been described, which may give refuge to dolphins displaced from highly-disturbed adjacent waters.

Individual strategies are determining factors to gain insight on harbour and grey seals' foraging ecology

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Identifying the foraging behaviour of marine top predators with accuracy is essential to study their ecology. Individual strategies often have a critical influence on foraging ecology, and lacking to take them into account can bias the identification of feeding areas and behaviour at the colony scale. Our study aimed at identifying the foraging strategies of eight harbour seals (*Phoca vitulina*) and six grey seals (*Halichoerus grypus*) fitted with GPS/GSM tags by analysing their horizontal movements and dives, as well as stable isotopes ($\delta^{15}N$) in their whiskers. All harbour seal individuals exhibited foraging dives close to their haulout site (HL) (11±9.8km in average) in similar areas. $\delta^{15}N$ signatures were similar among individuals ($p>0.05$, 16.3±0.5‰) suggesting that they all foraged on prey of the same trophic level. Grey seals exhibited stronger inter-individual differences in foraging strategies, as shown by $\delta^{15}N$ signatures ($p<0.001$). Two main types of strategies were distinguished from a cluster analysis on stable isotopes. Two grey seal individuals presented foraging strategies similar to the harbour seals' one: their foraging areas were close to HL (17.9±10.4km) and they displayed a similar trophic position ($\delta^{15}N$ signature of 16.5±0.8‰). However, the four other grey seals foraged much further (foraging dives at 145.7±75.4km from HL) and displayed a higher trophic level ($\delta^{15}N$ signature of 17.9±0.5‰). This was supported by individual Minimum Cost of Transport Speed (MCTS, calculated from dive parameters) which was lower for individuals foraging closer to HL (1.6±0.1 $m.s^{-1}$ for harbour seals and 1.7±0.1 $m.s^{-1}$ for two grey seals) and higher for those foraging further (2±0.1 $m.s^{-1}$ for the four other grey seals). This study clearly identified intraspecific differences in individual grey seal foraging strategies. This suggests that identifying such differences in behaviour within a marine top predator species is essential to better interpret their foraging ecology at the colony scale.

Spatial distribution and connectivity of common bottlenose dolphin (Tursiops truncatus) communities along the eastern Adriatic coast

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Long-term photo-identification studies on bottlenose dolphins (*Tursiops truncatus*) at two sites in the Croatian Adriatic Sea, corroborated with a genetic study, suggest that the population is structured into discrete local communities. However, the two study areas were far apart and did not encompass whole home ranges of the studied local communities. In 2013 field work expanded to include a new study area between the two existing ones. We used photo-identification data from the three contiguous study areas to determine social structure of bottlenose dolphins and to examine the spatial distribution and connectivity of the identified communities. The hierarchical cluster analysis, based on half-weight indices (HWI) of dolphin pairs, revealed three communities separated at HWI=0.011 threshold. We then used 95% Kernel Density Estimator (95% KDE) to estimate home ranges for individuals and calculated home range overlap ratios for each pair of individuals. The HWIs and 95% KDE overlap ratios were moderately correlated (r=0.58) and significantly higher for pairs within the same community than between communities, indicating both social and spatial segregation. The 95% KDE home ranges calculated for each community showed little to no overlap between them. The analysis of movements revealed that most individuals stay within their respective community's home range. The movements of individuals between community home ranges were low (3.8%) and sporadic. Based on results, at least three socially and spatially distinct, but not isolated communities inhabit the 300 km stretch along the Croatian Adriatic coast encompassed with this study. The future research and monitoring programs may profit from knowledge of their putative home range boundaries, as it can be accounted for in study design. Ultimately, the management of four Sites of Community Importance, which overlap with the three community home ranges, may use these results to

tailor conservation plans to specific needs of each community.

Spatial and temporal variation occurrence of Risso's dolphin (Grampus griseus) in southwestern coast of Portugal
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The presence of Risso's dolphin (*Grampus griseus*) has been documented in the Azores and Madeira archipelagos, but in mainland Portugal it has been very poorly studied. From 2005 to 2018, a total of 4342 opportunistic surveys were carried out by a qualified observer on board dolphin watching tours in Sagres, resulting in a total of 7375,79 h of search effort under Beaufort Sea state £3 and up to 12 Nm off the coast. Weather conditions, GPS position and survey track, depth, SST, group size and composition, and behaviour were collected.

Sighting Index (SI), Abundance Index (AI) and Kernel estimates were calculated in order to investigate the seasonality and habitat use. During the study, 83 Risso's dolphin sightings were registered, of which 72 during search effort. Sighting distance to shore ranged between 0.3 and 9.3 Nm (4.06 ± 0.27) and depth between 20 and 716 m (118.74 ± 13.18) (n=83). The occurrence of the species was not constant through time, being absent in two study years, and not recorded in the months of January, March or December, which can however be a result of a smaller effort during winter months. Spring (SI=0.016) and Autumn (SI=0.017) showed peaks in sightings (n=72), possibly related to seasonal migrations/movements due to changes in water temperature and prey availability.

Estimated group size varied between 1 and 100 (10,70 ± 1.48) with no significant variance between seasons. Calves were present all year round, which could indicate proximity to reproductive areas which are not well identified yet.

Although studies based on opportunistic surveys have limitations, they provide highly valuable information that otherwise would be unavailable. In this case, this opportunistic platform allowed the first insight into the coastal occurrence of this species in Southwest Portugal and during a relatively long period (14 years).

Recolonization of a grey seal /Halichoerus grypus/ in Polish Baltic coast
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Together with the increase of the grey seal *Halichoerus grypus* number in the Baltic Sea the recolonization of its southern coast has been observed. First appearance of several individuals on the islets in the mouth of Vistula river has given an opportunity to record the settlement process of this unique haul-out. Year-round video monitoring station was established in 2010. The results collected so far allow to estimate the size of the seal group over the seasons but also provide the knowledge on their behavior in changing environment, inter-individual interactions, life cycle and human activity contributing to the disturbance in the area. These information is crucial for the development of a guidelines for touristic boats and enable direct reaction on disturbing human behavior. Moreover records of large groups of moulting seals in April and early May may contribute to re-consideration of the period of international census of grey seals in the Baltic Sea so far performed during the agreed moulting season at the turn of May and June.

Evidence of intestinal polycyclic aromatic hydrocarbon (PAH) DNA adduct formation links PAH exposure to gastrointestinal cancers in St. Lawrence Estuary Beluga.
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Exposure to cancer-causing PAHs produces covalent PAH-DNA adducts. DNA adducts constitute biomarkers of exposure, which are also considered necessary for progression to cancer. In the Saguenay River of the St. Lawrence Estuary (SLE, Quebec, Canada) a unique population of beluga was exposed for 50 years (1926 to 1976) to large amounts of PAH waste dumped directly into the river from aluminum smelters using the Söderberg process. For many subsequent years high levels of PAHs were documented in the atmosphere, the river sediments and the beluga food supply. These exposures are considered etiologically related to gastrointestinal epithelial cancers observed in 7% of 156 mature (>19 yr old) adult beluga stranded between 1983 and 2012. Because PAH-DNA damage is chemically stable, we hypothesized that SLE beluga intestine would contain DNA with a measurable burden of PAH damage. To explore this possibility, we incubated sections of paraffin-embedded intestine with antiserum specific for DNA containing bases modified (damaged) with carcinogenic PAHs. We examined paraffin blocks of intestine taken from beluga in the contaminated areas SLE (n=51, 0-63 yr) and Cook Inlet (CI) Alaska (n=4, 0-26 yr), and beluga from relatively uncontaminated areas including Arctic regions (Eastern Beaufort Sea, Eastern Chukchi Sea, Point Lay Alaska) and aquaria (n=20, 0-46 yr). Nuclear light-to-dark pink color, indicating the presence of PAH-DNA damage, was found concentrated in intestinal crypt epithelial lining cells. The H-Scoring system, applied to coded photomicrographs, confirmed that SLE and CI beluga had levels of intestinal PAH-DNA damage significantly higher than the Arctic and aquarium beluga ($p = 0.003$ for SLE, and $p = 0.02$ for CI). In addition, intestinal epithelial cells from 4 SLE beluga with intestinal cancers contained particularly high levels of PAH-DNA damage, suggesting a link of causality between PAH exposure and intestinal cancer in SLE beluga.

Alternative of species distribution models using R and Python in the study of bottlenose dolphin in the Veracruz Reef System, Mexico.

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The study of biotopes and the species distributions for communities have concerned the biogeography area to understand the existence, as well as the flow of life of the flora and fauna, considering climatic, biotic and environmental features for their aims. This refers that one of its tasks focuses on gestating predictive models for the activity of the specimens within a defined geographic space, through environmental data collected and under the basis of statistical and mathematical techniques. This research study was designed to present as an alternative the Python and R Project programming languages for the generation of species distribution models since they are free software and with accessibility to perform data analysis in various areas. The analysis was carried out from the information obtained about the bottlenose dolphin (*Tursiops truncatus*), a species which lives in the Veracruz Reef System located in the Gulf of Mexico, for the manifestation of the importance of this species and an identification of the distribution patterns within the residing biome. According to the data analyzed, three models were obtained, the first to locate the distribution of the dolphin, the second which predicts the presence of the species and finally the third model that calculates the absence of the dolphins. In conclusion, the programming languages used for this application had good efficiency and effectiveness to analyze this type of data. In addition, extensive results such as data cleaning, creation of vectors, models, predictions and visual representations (maps) were obtained using the different libraries and packages.

The times, they are a'changin: How longitudinal parturition dates of Scottish grey seals Halichoerus grypus affect colony birth curves.

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Synchrony in breeding can structure sub-groups within a population. Timing of breeding at UK grey seal colonies follows a clockwise cline from

SW to SE. In Scotland, mean pupping date (derived from aerial survey, 1986-2016) at a colony with declining pup production, North Rona (NR, Outer Hebrides) varied from 06Oct-16Oct, at the Isle of May (IM, Firth of Forth) with recently stable pup production, it varied between 26Oct-05Nov.

Colony-specific mixed models were used to investigate how a mother's parturition date (PD) was affected by intrinsic variables (maternal identity, age, mass at parturition) and a Year effect in longitudinal data from known individuals, over nearly 4 decades (1978-2014). We asked if observed changes in colony average pupping dates were likely due to changes in the age/size composition of animals present or to common responses to large scale environmental (Year) effects.

Age and mass ranges of sampled mothers were similar but on average NR mothers were older and heavier: (mean±sd: NR 19.2±6.4yr, range 4-36yr, n=101: IM 16.6±6.3yr, range 5-40yr, n=135: NR 187±22kg, range 127-253kg : IM 176±24kg, range 109-264kg). At each colony, mean pupping dates of sampled mothers tracked colony means.

At NR, PD was highly variable between individuals, became earlier with maternal mass and became earlier with age . At IM, PD was also highly variable between individuals and became earlier with maternal mass, but varied as a quadratic function of age. Linear Year effects in mixed models indicated a mother's PD became later at NR (+0.26d/yr) but earlier at IM (-0.1d/yr), suggesting different regional influences.

Based on effect sizes, NR's gradual increase in mean birth date is likely from loss of older females and environmental effects, while IM mean birth dates vary more than expected in a numerically stable colony and could indicate intermittant breeding colony use by some mothers.

Navigating through people and systems to enable marine mammal science and conservation - a Malaysian/Southeast Asian Odyssey

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Marine mammals do not hold the same charismatic appeal in Southeast Asia as they do in the West. Here are insights from a young Malaysian cetacean scientist who chose a path much less traveled in her country; how she had to persist in the face of naysayers and societal challenges to enable her to do the marine mammal science and conservation work that she aspired to. She shares what it takes to emerge as a national marine mammal authority in her own right.

Shining the spotlight on a highly overlooked porpoise within an IUCN important marine mammal area – Indo-Pacific finless porpoises (Neophocaena phocaenoides) in the Langkawi Archipelago, Malaysia, deserve conservation attention.

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The Indo-Pacific finless porpoise (*Neophocaena phocaenoides*) is one of 27 species of marine mammals found in Malaysian seas. Although an ubiquitous species throughout much of Southeast Asia, scientific information on finless porpoise distribution, habitat use, feeding habits and bycatch risk remains limited. Coupled with the species' apparent lack of charisma (i.e., small size, inconspicuous behaviour) when compared to delphinids and whales, it does not attract the same attention warranted to those other cetaceans, yet there are growing concerns over its conservation status. The Langkawi Archipelago, a UNESCO World Geopark, is a cluster of tropical islands off the north-western coast of Peninsular Malaysia. In 2018, the area was recognized as an Important Marine Mammal Area (IMMA), largely owing to the significant presence of finless porpoises, with Langkawi considered as one of the most ideal locations in the region to observe this elusive species. Systematic boat-based surveys in 2010 – 2013 totaling 117 survey days, 5498 km and 370 h of search effort found that the species was the most frequently encountered cetacean in Langkawi (n = 294 sightings), with an estimated abundance of 900 – 2000 individuals in an area measuring 1616 km^2. Boat-based surveys in 2016 – 2018 also found that the porpoises are still the most frequently encountered cetacean species in Langkawi (n = 148

sightings). Group sizes ranged 1 – 73 individuals, being some of the largest groups ever recorded in this region. However, 17 cases of dead porpoises recorded since 2010 (plus probably more unrecorded), with three occurring within the span of four days in 2018, puts the species' conservation status into concern. A Bycatch Risk Assessment will be presented highlighting the magnitude of risk the porpoises face in Langkawi. It is necessary that conservation attention be given to this highly overlooked porpoise both in Langkawi and the overall IMMA.

Strong impact of epizootics on long-finned pilot whales (Globicephala melas) in Strait of Gibraltar

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The Strait of Gibraltar is one of the world's areas with more maritime activity, and cetaceans inhabiting this area, as is the long-finned pilot whale population, are threatened by noise and chemical pollution, overfishing and collisions by the many boats crossing the strait. One of the greatest threat identified until now for the species in the Mediterranean are epizootics that severely affect the most sensitive vital rate in long live species: adult survival. By multi-event analysis of a 16 years' database of photo-identification capture-recapture data, we analyse adult survival in the Strait of Gibraltar resident population and evaluate the effects of epizootics. We identify the severe effect of an epizootic morbillivirus episode occurred in 2006, but we also evidence a second collapse in survival in 2011, probably due to an another morbillivirus epizootic. These episodes seem to differently affect both sexes, with females being less affected than males. Interestingly, morbillivirus epizootic not only sharply decreased survival after the episode but the effect extended over time, probably showing a post-epizootic chronic effect. Epizootics seem to be dramatically frequent in the Gibraltar area. These lethal disease outbreaks are often the consequence of herd immunity decline that could be linked to anthropogenic threats like organochlorine contamination, thus the strong maritime activity and contamination at the area may put this population and the whole ecosystem at higher risks of epizootics. We warn about the conservation status of the long-finned pilot whale population and suggest revising their conservation classification at a local scale. We also advise to apply measures to reduce contamination on this nutrient-rich to improve conditions for many marine species inhabiting this area.

Prevalence of ulcers provoked by Anisakis spp. in cetaceans from the Northwest Atlantic: A signal of a long-term increase in anisakis populations?

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Species of nematodes of genus *Anisakis* infect cetaceans worldwide. The life cycle includes crustaceans as intermediate hosts, fish and cephalopods as paratenic (transport) hosts, and cetaceans as definitive hosts, in which worms typically reproduce in the stomach. These nematodes are of significant health concern because they can infect humans, provoking anisakiasis, and/or eliciting allergic reactions. In cetaceans, individuals of *Anisakis* spp. often generate ulcers, which, in severe infections, can perforate the stomach wall causing peritonitis and, eventually, death. In this study, we report on ulcers provoked by *Anisakis* spp. in cetaceans stranded in the Northwest Atlantic along 2017-2018, and compare the frequency of occurrence and severity of these ulcers with data from a study carried out in cetaceans stranded in the same area during 1990-1996. Open ulcers were found in 32 of 43 short-beaked common dolphins, *Delphinus delphis*; 1 of 7 bottlenose dolphins, *Tursiops truncatus*; 3 of 5

striped dolphins, *Stenella coeruleoalb*a; 1 of 3 harbor porpoises, *Phocoena phocoena*, and 0 of 1 long-finned pilot whale, *Globicephala melas*. In the cetacean species with an acceptable sample size, i.e. common dolphin, the mean abundance of ulcers per dolphin was 1.1 ± 0.9, and their average diameter 24.9 ± 16.7 mm (range: 3-80 mm). Scars of old ulcers were found in 3 additional common dolphins. Areas with extensive fibrosis (maximum diameter ranging from 50 to 210 mm) occurred in 9 dolphins. Compared with common dolphins in the period 1990-1996, there has been a very significant increase of ulcer prevalence (74.4% vs. 15.0%) and abundance (1.1 vs. 0.22). Although we cannot rule out that common dolphins currently suffer from more environmental stress, thus being more susceptible to the pathological effects of *Anisakis*, these results support the possibility that *Anisakis* populations have increased in the area over the last decades.

Are lungworm infections in the striped dolphin, Stenella coeruleoalba, higher during DMV outbreaks?

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Mediterranean striped dolphins, *Stenella coeruleoalba*, suffered two mortality outbreaks caused by the dolphin morbillivirus (DMV) in 1990-92 and 2007-08. In the first outbreak, at least two contributory factors have been linked to non-random mortality caused by the virus. In particular, high level of pollutants and inbreeding depression could have enhanced susceptibility of individual dolphins to DMV effects. An open, interesting question is whether dolphins killed by DMV also harboured unusually high parasite loads. This pattern could either reflect low immunocompetence and/or play a contributory role in generating mortality. In this study, we examined this hypothesis by focusing on lungworm infections in 92 striped dolphins that stranded along the Mediterranean coast of Spain in the summer and autumn between 1987 and 2018. Animals were grouped into three periods, i.e., dolphins that stranded in 1990-92 (first epizootic); dolphins that stranded in 2007-08 (second epizootic); and dolphins from other years (non-epizootic). Prevalence and intensity of lungworm infections were analysed using GLMMs with period, host body length and gender as fixed effects and year as a random effect. Although the intensity of lungworm infection in the first epizootic period (mean intensity: 42.41, 95% CI: 27.50-69.68) was higher than that from the second epizootic (mean intensity: 19.00, 95% CI: 8.50-29.50) and the non-epizootic period (mean intensity: 34.96, 95% CI: 19.09-62.09), only host body length (regardless of period) had a statistically significant effect on infection parameters. Accordingly, we found no evidence that dolphins affected by DMV had unusually high burdens of lungworms. However, we must bear in mind that the non-epizootic sample consisted of stranded dolphins, which do not necessarily represent the natural population and, therefore, the purported association between parasitism and DMV is open to further analysis.

The coastal acoustic buoy: A new tool for remote and real-time acoustic monitoring.

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The Coastal Acoustic Buoy (CAB) represents a new generation of passive acoustic monitoring devices for marine species and underwater noise monitoring. There are currently two versions; a lightweight design housed in a floatation collar that can be deployed from a small boat and a robust cylindrical pack that can be installed on existing large buoys, therefore enabling deployment in more offshore areas. The lightweight version has a battery life of 14 days and the installation version has a battery life of 35 days. A choice of up to three channels and various sampling rates (maximum 500 kHz) provide multiple configurations and maximum flexibility. In conjunction with PAMGaurd software, marine mammal echolocation clicks, whistles and other tonal calls can be identified with existing detectors and classifiers designed for baleen whales, dolphins and porpoise. Modules can also be utilised measure ambient noise levels in rms, 0-peak, peak-peak and SEL across a customisable range of frequencies and time scales. Processed data can be sent real time using radio link to a base station or near real time via the cellular network and raw acoustic data is stored onboard. To date, CABs have been successfully deployed in Hong Kong, for Indo-Pacific humpback dolphins (*Sousa chinensis*) and the USA, to detect harbour porpoise (*Phocoena phocoena*) and orca (*Orcinus orca*). As with all PAM systems, the range of detection is dependent on species and site-specific conditions. Such a

flexible tool can provide large amounts of information in a relatively short period of time on marine mammal species that are elusive, rare or, most importantly, of conservation concern. Thus, conservation authorities are empowered to make meaningful management decisions in shorter time periods.

Are current European Environmental Impact Assessments (EIAs) sufficient for odontocete conservation during offshore wind farm development?

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Offshore wind farms (OWFs) are a growing strategy across Europe to meet renewable energy goals. Many OWFs are located in coastal environments where they overlap with the ranges of several cetacean species, creating a potential conflict between energy production and species habitat requirements. A key tool to support effective environmental stewardship in Europe is the Environmental Impact Assessment (EIA), as required by European Directive 85/337/EEC. As a measure of accountability and preparation, EIAs are used to gauge possible human impacts on the environment and allow for mitigation techniques to be applied as needed. However, current guidelines for EIAs are not a precise mechanism and are open to interpretation regarding implementation and Developer reporting requirements.

The goal of this study was to examine previously conducted EIAs focused around OWFs with regards to cetacean conservation within Europe and to propose revised procedures and improved accountability based on the outcome of the review. This study examined five OWFs within the North Sea and adjacent areas that have been granted consents over the last 18 years: three in the United Kingdom and two in Denmark. This included Nysted, Horns Rev II, Beatrice, Teesside, and the Blyth Offshore Demonstration Project. Several different issues were identified in the review, including inadequate baseline/post-construction monitoring, weak enforcement/penalties, incomparable EIA designs, incorrect species focuses, poor documentation, use of broad blanket statements, and a lack of language standardisation. These are all issues that may hinder efforts to review and improve OWF developments.

It is recommended that EIAs maintain strict levels of standarisation allowing for comparability, flexibility, and adaptability. Simultaneously, with well-funded and highly-structured monitoring schemes, EIAs can provide practical assessments of potential negative ecological effects from OWF developments. Coupled with appropriate legislation and policies, these recommendations will assist the sustainable development of OWFs for cetaceans in the UK and elsewhere.

Evidence for a fission-fusion society in a population of rough-toothed dolphins (Steno bredanensis) in Guerrero, SW Pacific Mexico.

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Toothed whale populations often exhibit complex association patterns and social structure that are important to understanding their biology. Studies of well-studied species, such as bottlenose dolphins, sperm whales, and killer whales demonstrate that sociality varies across different regions and between species. The lesser known rough-toothed dolphins typically inhabit deep oceanic waters in understudied regions. Because of this, and despite indications of complex sociality, the degree to which their populations are structured in most areas is unknown.

We evaluated the social structure of a population of rough-toothed dolphins in the Southwest Pacific Mexican state of Guerrero. Sighting (n = 82) and photo-identification data gathered during boat-based surveys from 2014 to 2018 (1688 hours of survey effort) were analyzed. Some individuals were observed interannually (up to 4 different years), suggesting site fidelity and residency. The half-weight index was used to quantify the strength of associations between all resighted individuals (76 individuals of 175 dolphins identified). Permutation tests showed strong evidence for non-random social structure, and estimation of social differentiation suggested a well-differentiated society (S = 0.73). Cluster analysis revealed 7 different clusters, with a modularity index indicating significant divisions in the population (Q = 0.34). These results suggest that rough toothed dolphins form a fission-fusion society where animals associate non-randomly to form groups of varying size and composition over time. Associations between individuals may be influenced by ecological factors and/or kinship. Our results suggest coastal rough toothed dolphin

social structure is comparable to other coastal delphinids such as bottlenose, Guiana or Hector's dolphins. Additional study would be required to further test this hypothesis. The relatively easy access to this particular coastal population and calm environmental conditions provide a rare opportunity to describe social structure and determine its importance to their lives.

From settlers to subspecies: Genetic differentiation in Commerson's dolphins between South America and the Kerguelen Islands.

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The Commerson's dolphin *Cephalorhynchus commersonii* includes two recognized subspecies: *C. c. commersonii* from southern South America and the Falkland/Malvinas Islands, and *C. c. kerguelenensis*, restricted to the subantarctic Kerguelen Islands. Following the West to East model of dispersal/diversification proposed for the genus, the latter subspecies is thought to have originated from a long distance dispersal event from South America. In order to improve the evaluation of this biogeographic scenario, new samples from southern Chile (n=6) and the Kerguelen Islands (n=23) were added to previously published mtDNA control region sequences from South America (n=292) and the Kerguelen Islands (n=11). To complete the range-wide distribution, new samples were also added from the Falkland/Malvinas Islands (n=52), adding up to a total of n=384 samples. From the 28 haplotypes identified, four were private to the Falkland/Malvinas Islands and three to the Kerguelen Islands. Significant phylogeographic structure was found among the three areas, being much higher between Kerguelen Islands and South America together with Falkland/Malvinas Islands (Φst=0.44-0.51) than between South America and Falkland/Malvinas Islands (Φst=0.11-0.14). Using the frequencies and phylogenetic relationships of the haplotypes, the proposed historical biogeographic scenario of colonization was tested with Approximate Bayesian Calculations. Initial trials show that the dispersal event from South America and Falkland/Malvinas Islands to Kerguelen Island may have occurred in the early Holocene and was followed by a population expansion process in Kerguelen Islands. These results support the model of postglacial colonization of Kerguelen by South American *C. commersonii* followed by a still ongoing differentiation process.

Occurrence and distribution of False killer whales (Pseudorca crassidens) in Central America

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False killer whales (*Pseudorca crassidens*) is a poorly known species with "near threatened" IUCN status. Knowledge is lacking on their movement

patterns and social structure. Little data is available on this species along coastlines as it is a pelagic species. and no data is specifically available in Central America. In order to get more insights on their general ecology and movement patterns we compared the photo-identification catalogue and investigated their occurrence in Nicaragua, Costa Rica and Panama. Data were gathered during boat based surveys on three sites in Central America between 1999 and 2017. A total of 36 sightings were made in the three countries (3 in Nicaragua, 27 in Costa Rica and 6 opportunistic sighting in Panama) covering a total of 465 hours over 3 years of effort in Nicaragua and 6100 hours from 2001 to 2015 in Costa Rica. Out of 36 sightings, only 16 sightings had photo-identification data. No recapture was made within and between sites and a total of 68 individuals were identified. Average group size was 10 in Nicaragua, 10 in Panama and 35 in Costa Rica. We recommend to include more data from adjacent countries to understand the distribution and occurrence of false killer whales in Central America. This is the first known attempt to characterize false killer whale population in Central America.

Clinical assessment of bone density in the common bottlenose dolphin, Tursiops truncatus

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Common bottlenose dolphins, *Tursiops truncatus*, are utilized as indicators of ecosystem health in long-term research projects both through post-mortem evaluation of beach-cast individuals and capture-release health assessments. To establish bone density as a useful health and life history parameter for the bottlenose dolphin, a primary target skeletal site in the radius of the dolphin pectoral flipper was comprehensively defined and a normative reference dataset was developed for the species. Bone mineral density (BMD) was measured in radii from 280 dolphins using dual-energy X-ray absorptiometry (DXA). BMD throughout the radius was analyzed and a single region of interest (ROI) was selected that had a high correlation to the density of the overall bone (R^2=0.98). Traditional methods for bone density measurement, such as DXA, utilize radiographic (X-ray) scanners that have limited potential in open-water field settings due to inherent limitations of access, regulation, and the radiographic nature of the technology. Alternatively, quantitative ultrasound is portable, non-invasive, and does not expose patients or technicians to radiation, thus making it an ideal diagnostic tool for field applications. In laboratory measurements on disarticulated flippers collected from beach cast dolphins, a strong correlation was established between bone density as measured with X-ray and quantitative ultrasound (R^2=0.93). Differences in BMD values for male and female dolphins, left and right flippers, dolphins from different geographical regions, and dolphins with varying nutritional status were examined. Initial trials to develop clinical protocols and demonstrate the ultrasonic technique as truly non-invasive were conducted on managed care dolphins under veterinary supervision. Successful assessments were subsequently conducted to ultrasonically assess BMD in live, free-ranging dolphins during capture-release health assessments during 2014-2019. Development of this technology enables assessment of dolphin bone tissue to become part of the armamentarium of biologists and veterinarians and additionally broadens the understanding of dolphin and overall ecosystem health.

Defining residency: Can a standardized approach with photographic-identification data be used to classify site fidelity patterns for coastal and estuarine small cetaceans?

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Residency is a qualitative term used heavily in peer-reviewed literature to classify marine mammals' recurring use of habitat or localized movements; however, there are few systematic criteria or quantitative metrics that have been used across studies and/or species to define residency. The ability to apply standardized metrics and classify residency is essential for the development and application of appropriate management strategies. The U.S. Marine Mammal Protection Act requires designation and management of individual populations, and estimates of anthropogenic serious injuries and mortalities (i.e., takes) to each respective population. If the estimated takes exceed a sustainability threshold, additional management and conservation measures may be required. In the

Southeastern U.S., common bottlenose dolphins (*Tursiops truncatus truncatus*) are particularly challenging with numerous coastal and estuarine populations that in some cases have overlapping ranging patterns. A standardized definition of residency for these populations is necessary to assign serious injuries and mortalities accurately, and assist with population delineations that are based primarily upon genetics with supplemental photo-identification and telemetry data. The goal of this study was to conduct a review of marine mammal literature from 1995-2018 that provide definitions or metrics for residency and/or site fidelity. "Residency metric scenarios" were then developed from compiled residency definitions to quantify the best descriptor of population movements using long-term photo-identification data. In Savannah, Georgia, the numbers of resident animals ranged from 39 to 125, highlighting the differences among various scenarios. These scenario outcomes were used to develop a universal residency definition recommendation with metrics that are best suited for coastal and estuarine common bottlenose dolphins in the Southeastern U.S., with the potential applicability to other small cetacean populations worldwide.

Genomic divergence of coastal bottlenose dolphins (Tursiops australis) in southern Australia is driven by strong environmental gradients.

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Environmental features have long been thought to drive patterns of fine-scale genetic differentiation in coastal bottlenose dolphins. With the growing application of genomic methods for non-model species, associations between dolphin genetic variants and environmental features can now be empirically tested. We utilised a high-quality genomic dataset of over 8,000 single nucleotide polymorphisms (SNPs) to carry out the first genome-environment association (GEA) analysis in the recently proposed bottlenose dolphin species, the Burrunan dolphin, *Tursiops australis*. Strong sea surface temperature (SST) and salinity gradients along the southern Australian coast were revealed as the most influential variables in driving genomic divergence in these dolphins. We identified 241 loci putatively under selection and possibly involved in local adaptation to marine habitats across the region. In particular, differing conditions between and within South Australia's gulfs and embayments may be driving the adaptive divergence of the dolphins across geographical scales as small as a few hundred kilometres. Functional annotation of these loci has revealed potential selection on several genes related to sodium-induced ion transport, and with adipogenesis, which may relate to adaptations of the dolphin populations to salinity and SST heterogeneity, respectively. Since the classification of *T. australis* as a separate species is still controversial, it is important to improve knowledge about these dolphins, particularly in regard to drivers of genomic divergence and local adaptation. This study also allows a better understanding of the ability of bottlenose dolphins to adapt to changing environments, which is particularly crucial in the face of ongoing climate change.

Diving behaviour of migrating ringed seals crossing ferry line in Moonsund

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There is a growing concern about the ship induced continuous anthropogenic noise that can negatively impact the sound sensitive species. Shipping noise has the potential for auditory masking of acoustically active marine mammals by reducing their communication space. West Estonian Archipelago and Gulf of Riga are inhabited by a below Good Environmental Status population of the Baltic ringed seals (*Pusa hispida botnica*). The seals travel regularly from the haul-out areas in the archipelago through a shallow and narrow (6 km wide) Moonsund to forage in the Southern part of the Gulf of Riga. A busy ferry line connecting the Muhu island to the mainland crosses the vital migrating route of the seals. The migration behaviour of several ringed seals were studied with telemetry data recorders. The locations of the ferries were obtained from the Automatic Identification System and their emitted sound levels were measured in situ to derive source level. Rate of co-occurrences of the animals and ferries was found from their spatial and temporal overlap. The seal telemetry data includes GPS resolution spatial data, dive depths, dive durations and times spent at sea surface. The measured movements and dive profiles allowed to assess the diving effort and

behavioral responses to the noise emitted by the ferries. This enabled the comparison of behavioral patterns in a natural and noise disturbed environments. Sound propagation modelling made it possible to assess sound exposure level of the diving animals in the water column. The result indicates to a possible avoidance behaviour and to an increase in energetic cost during migration and foraging. The habitat quality and integrity is the key contributor to the population status of this conservation-reliant species with a very limited distribution range in the Baltic Sea.

Pre-whaling population structuring and diversity of blue whales (Balaenoptera musculus) in the high latitudes of the North Atlantic

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During the 20th century, blue whales (*Balaenoptera musculus*) were heavily exploited by the commercial whaling industry, reducing the population to less than 0.1% of its pre-exploitation abundance. Globally, blue whales are divided into four sub-species based on morphological and geographical distinctions. However, their sub-species and population divisions are poorly understood and the distinctions between them are vague beyond their presumed geographical separation. Assessments of population structure and genetic diversity only exist for North Pacific and Southern Hemisphere blue whales in the literature. Northern Indian Ocean blue whales have little available data and no such evidence is available for North Atlantic blue whales (*B. m. musculus*). To conduct this study, I identified and assembled a dataset of 23 North Atlantic blue whale samples dating from the early whaling period (1865-1953), available through museum collections, which I have sampled and analysed. The DNA analysis of these bone samples provides a rare opportunity to establish the genetic diversity and population structuring of blue whales across the North Atlantic at the start of modern whaling, to measure how genetically distinct this population is from other blue whale populations worldwide and to estimate how long ago the ancestors of this population colonised the North Atlantic Ocean. Here, I describe the mtDNA (control region) diversities of North Atlantic blue whales in order to measure pre-whaling diversity and population structuring within the North Atlantic as well as assessing population connectivity and timing the divergence of this population from other blue whale populations. No evidence of distinct blue whale populations within the North Atlantic before whaling has been found as there was no significant differentiation between Eastern and Western North Atlantic populations. North Atlantic and North Pacific blue whales should be considered as distinct sub-species given their high levels of inter-population differentiation, the levels of divergence seen between the North Atlantic and North Pacific.

AragoJ – A free, open-source software to aid single camera photogrammetry studies

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Single-camera photogrammetry (SCP) is a well-established procedure to retrieve quantitative information from objects using photography. It is often used in biological sciences when direct handling of individuals is unpractical, which is the case in many marine mammal studies. In fact, unprecedented access to aerial imagery from remotely operated aircrafts has boosted morphometry studies based on SCP. Studies using SCP can be of two types: 2D photogrammetry, where distance and angle measurements are used to quantitatively describe an object's attributes, and 3D photogrammetry, where object true shape is reconstructed from landmark coordinates. Paradoxically, software packages to deal with the complex calculations demanded by 3D photogrammetry are widely available, but software specifically designed to aid in 2D photogrammetry are scarce, and are often tailored for specific problems, narrowing their applicability. In 2D photogrammetry, workflow usually involves some

or all of the following steps: 1) calibration and correction of picture distortion when using non-metric cameras; 2) measuring the relevant structures in the photographs; 3) scaling measurements, either by using a scale in the image or based on camera parameters and distance to an object; 4) transcribing measurement and metadata to a database. Researchers often utilize diverse software to complete these tasks, increasing processing time and chances of transcription errors. Here we present a new cross-platform open-source software, AragoJ, that integrates and streamlines photogrammetry workflow. The software includes several measurement tools admitting both forms of scaling. Metadata inscribed in digital images EXIF information is easily selectable for export. It includes a module for self-camera calibration, and produces undistorted images. It also includes a module for storing mathematical expressions that can be called inside the software. Measurements, calculation results, and image metadata can be exported as a csv file. In tests, processing time using AragoJ was halved when compared with a competing methodology.

Estimating abundance trends of humpback whale population in Southeast Alaska from 2008 to 2019.

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In 2008, Calambokidis et al published a collaborative, ocean-basin-wide study on the abundance and distribution of North Pacific humpback whales (SPLASH; Calambokidis et al 2008). This study created widespread enthusiasm among the scientific community showing that humpback whale numbers had risen in the North Pacific by an order of magnitude from ~1,200 individuals estimated shortly after the cessation of whaling (Rice & Wolman 1982) to ~20,000 four decades later. Similar increases in whale abundance elsewhere, lead to the removal of 10 of the world's 14 humpback whale stocks from the US Endangered Species List. However, recent observations in Southeast Alaska, a principal foraging ground for North Pacific humpbacks, have revealed declines in whale abundance, record-low calf sightings, and an increase in the number of whales in poor body condition which appear to be foregoing their migration to winter breeding grounds. Whether this trend is true, and further, whether it is linked to underlying changes in the marine ecosystem remains unclear. Resolving these issues is crucial to understanding the future trajectory of whale populations and establishing appropriate management strategies. Furthermore, as indicator species, changes in whale abundance can signal underlying changes in their ecosystem. Therefore, assessment of abundance of humpback whale population in Southeast Alaska can be a valuable tool for conservation and monitoring the health of our changing oceans.

In this study we compare abundance estimation of humpback whale population in 2008 versus 2018 and 2019 in Frederick Sound and lower Stephens Passage. In 2008, whales were surveyed from sets of stratified-random line transects across the summer, while in summer 2018 and 2019, systematic point transect surveys were repeated. Preliminary results show an estimated whale abundance of 228 (CV = 26.4%, 95% CI = 163-319) in 2008 and 155 (CV = 38.9%, 95% CI = 74-326) in 2018.

The impacts of ship noise in Eclipse Sound, Canada, on narwhal (Monodon monoceros) call rate.

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Cetaceans have the potential to be disturbed by anthropogenic noise. Little is known about how narwhal in the Eastern Canadian Arctic may respond to increased shipping in their summer calving grounds in August and September. In 2018, three passive acoustic monitoring (PAM) stations were deployed in Milne Inlet (two along the shipping lane and one 6 km away in Koluktoo Bay) over the open-water season to document narwhal vocal behaviour relative to ship traffic. A high-frequency cetacean (HF) auditory weighting function (Southall et al., 2019) was applied to calculate the broadband (10–31,500 Hz) noise levels. An automated call recognizer detected narwhal vocalizations; knocks (broadband pulses, produced singly or in a short series, <20 kHz), and low- and high-frequency whistles. Low- and high-frequency whistles and knocks were present in 1.2–8.0, 0.5–4.2 and 8.6–16.2 % of the recordings, respectively. Changes in the rates of these call types were analyzed in relation to ship location (automatic information system data, AIS). Along the shipping route, the knock rate increased when a ship was within 2 km of the recorder, and whistle call rates (high and low) decreased when a ship was

within 8-10 km of the recorder. These changes in vocal behaviour occurred when broadband levels exceeded 95–98 dB (HF) re 1 mPa. In Koluktoo Bay, knock rates increased slightly when a ship was within 12 km of the recorder. High and low whistle call rates decreased when a ship was within 9-10 km of the recorder. Broadband levels in Koluktoo Bay remained low regardless of shipping activity, never exceeding 10 dB above ambient levels. The insensitivity of narwhal hearing at low frequencies and the blocking of sound transmission by headlands along the inlet likely contribute to the absence of behavioural vocal changes until the ships were within 10 km.

Anticipatory and overnight whistling behaviour of bottlenose dolphins in human care

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Bottlenose dolphins are highly social marine mammals and vocal communication is an important way in which they maintain contact. They are the most common cetacean found in human care, and are therefore one of the most studied of the cetacean species. Nevertheless, their overnight vocal activity is not very well understood. One method to analyse change in vocal behaviour is to look at change in whistle production over time. Whistles are a major component of their vocal repertoire and are primarily used to indicate heightened excitement, arousal or stress. The set routines of a dolphinarium can result in anticipatory behaviour in the dolphins and understanding the changes in whistle behaviour in response to this could be a valuable animal welfare tool for dolphin-keeping facilities. Continuous overnight recordings were collected over 24 nights in May, July and August 2018 from 17:00 to 7:00 at the uShaka Sea World dolphinarium, Durban, South Africa. A signature whistle catalogue of 10 known signatures was created, eight of which were confidently allocated to eight of the 10 individuals. Whistle production was measured using total signature whistle counts as well as counts of other non-signature whistle categories. Preliminary results indicate an obvious trend in whistle production during pre-feeding, feeding and post-feeding activities, which suggests an increase in whistle production in response to the anticipation of the morning feed. Further results will indicate whether this trend is statistically sound using generalised additive models, and give the first account of nocturnal vocal behaviour of the dolphins at uShaka Sea World.

Occurrence and pathologies associated with foreign body ingestion in stranded cetaceans, Canary Islands.

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One of the major concerns in aquatic environment is the impact of marine litter. Plastic is the most prevalent item within marine litter and not only affects the chemical quality of the water but also impacts marine organisms. Currently, the presence of debris ingestion has been reported all over the world in different marine species, though little is known in cetaceans. In this research, we study the occurrence and pathologies associated with the presence of foreign bodies (FB) in stranded cetaceans in the Canary Islands during a sixteen years period (n = 465). Fifteen species were affected by FBs including eight out of the nine year-round species in the archipelago. A total of 36 individuals (7.74%; 36/465) presented at least one FB, being plastic the most common item found

(80.56%). Deep divers were the most affected group with *Grampus griseus* as the most affected species followed by *Physeter macrocephalus* and beaked whales. Two individuals of baleen whales were also affected (*Balaenoptera physalus* and *B. acutorostrata*). Ingestion of debris was lethal in 36.11% (13/36) of the cases presenting lesions such as stomatitis, bleeding ulcers, gastritis, perforations and impactions. As previous reports, no lesions were found in ten individuals which presented ingested FB. This is the first forensic study that, based on statistical analysis, define two risk factors for FB ingestion (poor body condition and deep diving behavior) and a protective factor (adult age).

Environmental factors affecting the Irrawaddy dolphin (Orcaella brevirostris) distribution in the Mahakam River, East Kalimantan.

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The Mahakam River in East Kalimantan, Indonesia, is typical of other tropical rivers in Southeast Asia but is distinguished by a riverine population of the iconic Irrawaddy dolphins, known locally as *Pesut*. Like many other tropical rivers in Southeast Asia, the Mahakam River is also facing problems from rapid development in rural areas, characterised by a massive conversion of peatland forest to oil palm plantation, an increasing number of mining activities, and ongoing development of settlements. These developments are likely to have had both direct and indirect effects on Pesut.

Water quality parameters and land use type from sites in the upper, middle, and lower sections of the Mahakam River were used to quantify relationships with between broadscale catchment land-use changes and river habitat changes while anthropogenic factors such as fishing pressure and other forms of human disturbance were also assessed in relation to dolphin distribution. The objectives of this analysis were to (i) quantify changes in water quality in relation to land use, (ii) investigate the key environmental factors associated with Pesut distribution and abundance in the Mahakam River, and (iii) integrate these findings with other information on dolphin ecology to make recommendations that support dolphin conservation management.

Over 1996–2017, the land use in the sub-catchments of government water quality monitoring sites demonstrated changes that reflected increasing concentration on total disssolved solids (TDS), followed by nitrite (NO2-N) and sulphate (SO4). The middle reach of the Mahakam River was indicated as the primary habitat for Pesut. Several land-use related water quality parameters appeared to influence dolphin distribution through indirect effects on prey distribution. Accordingly, conservation management of Irrawaddy dolphins in the Mahakam River should focus on factors influencing prey species productivity in the river, such as the formation of fish reserves.

Evidence for factors that shift virus from endemic to outbreak in ongoing circulation of both IAV and PDV within pinnipeds of the Northwest Atlantic

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The Northwest Atlantic has been a hotspot for pinniped viral infections for at least half a century. Of the 9 virus associated unusual mortality events that have been documented globally in pinnipeds, 6 have occurred in the Gulf of Maine. Each of the mortality events has been attributed to either Influenza A Virus (IAV) or Phocine Distemper Virus (PDV) and in both systems, it has generally been thought that unique seeding events initiated each outbreak. A

longitudinal analysis of stranded and rookery animals provides strong evidence that both IAV and PDV cocirculate endemically within the Northwest Atlantic. Both viruses are found within harbor (*Phoca Vitulina*), grey (*Halichoerus grypus)*, and harp (*Pagophilus groenlandicus*) seals, with no apparent species barrier to transmission. Both viruses have also been detected within the region during each year tested (2011-present). Serological evidence suggests high diversity in IAV throughout the years, with antibody recognition against nearly all hemagglutinin subtypes. In contrast, PDV shows a high degree of viral stability. Our recent genetic analyses suggest that PDV initially entered North America in 1988, underwent a split around 2002, and has since maintained two strains. The dominant strain has had no changes in the H protein since 2011 and does not appear to be under selective pressure in the ongoing UME. We hypothesize that the inherent pathogenicity of these viruses alone is not the sole determinant to initiate mortality events, but rather external factors that tip otherwise endemic virus toward mortality events.

First description of the cetacean community in French Guiana eez

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In the context of oil exploration development off French Guiana, three boat campaigns were conducted to study the little-known cetacean community. From July 2011 to June 2012, for four days every two months, GEPOG NGO conducted a campaign; COHABYS consultancy led a campaign for five days per month from January to May 2018; OSL NGO conducted their campaign for 17 days in June-July 2018 and 19 days in September-October 2018. Surveys efforts in favorable weather conditions (Beaufort ≤ 4) took place over 1953 km, 1491 km and 3140 km respectively. Fifteen cetacean species were identified. The total number of group sightings and encounter rates (number of group sightings per 100 km effort) were: 52 groups and 3.2±2.6 groups/100km for GEPOG, 17 groups and 1.0±0.7 groups/100km for COHABYS, 64 groups and 2.0±0.4 groups/100km for OSL. We identified the dominant species for each habitat *i.e.* accounting for more than 20% of the encounter rate in the habitat under consideration at least for one campaign. These dominant species were: Sotalia (*Sotalia guianensis*) in the coastal area (0-20m); bottlenose dolphin (*Tursiops truncatus*), Atlantic spotted dolphin (*Stenella frontalis*) and common dolphin (*Delphinus delphis*) on the shelf (20m-100m); bottlenose dolphin, spinner dolphin (*Stenella longirostris*) and pantropical spotted dolphin (*Stenella attenuata*) on the upper slope (100m-1500m); pantropical spotted dolphin and sperm whale (*Physeter macrocephalus*) on the lower slope (1500m-3500m). These species were observed all year round and mother and calf pairs were sighted for all of them but the common dolphin. Two sightings of humpback whale (*Megaptera novaeangliae*) mother and calf pairs were also recorded. These results provide strong evidence of the importance of French Guiana EEZ to a diverse and abundant cetacean community. Data are now being processed to identify the areas and seasons that should be given priority consideration for their conservation.

More than metronomes: Variation in diving behaviour of Cuvier's Beaked whales (Ziphius cavirostris).

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Cuvier's beaked whales are known for their extremely long and deep foraging dives, which are typically interspersed with a series of shorter, shallower non-foraging dives. To understand variation in this general pattern, we deployed satellite-linked depth-recording tags on 17 whales off Cape Hatteras, USA in 2017 and 2018 as part of the Atlantic Behavioral Response Study. Tags were optimised to record continuous data during any dive longer than 33 minutes and subsequent inter-dive intervals. We obtained 11,093 hours of diving data, including 4,635 dives. Twelve whales were exposed to sonar signals; we removed periods of the data records associated with this exposure from our analysis. Total dives per individual ranged from 71 to 524 (median 214, n=16). Generalised Estimating Equations, with Group ID as a blocking unit, showed significant variation ($p<0.001$) amongst individuals in dive depth, dive duration

and inter-dive interval, with multiple individuals demonstrating extreme outliers across variables. Dive shape, sex and season were also important predictors of dive depth with animals tagged in Spring diving on average deeper than those tagged in Autumn. Time budgets, based on time spent at depth, revealed that all whales spent more than half their time in a non-foraging state. Sequential dive durations were highly autocorrelated, and the proportion of long dives (greater than 59 minutes) varied considerably among individuals (0.16 to 0.82). Unlike some historical characterisations of diving behaviour in this species our results demonstrate considerable individual variation, which could be driven by a range of biological and environmental factors, including prey availability, sex and social behaviour. Our results are among the longest continuous diving records for Cuvier's beaked whales and suggest a level of behavioural plasticity that has important implications for defining baseline data for this species, particularly with respect to experimental exposure to anthropogenic noise.

Resighting and movement patterns of right whales (Eubalaena glacialis) sighted in an area designated for offshore wind energy development

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North Atlantic right whales (*Eubalaena glacialis*) are exposed to numerous human activities during their migratory movements. We studied right whales at a 3,671 km^2 site designated for wind energy development south of Martha's Vineyard and Nantucket (MVN), off northeast U.S.A, to provide baseline information to developers. We examined the distribution, demographics, residency, and movements of identifiable right whales before and after they occurred at MVN using data collected from 232 aerial surveys and 42 days of opportunistic observations in 2011-2019. Sighting rates (animals/1000 km) were significantly higher in the spring than any other season ($p < 0.05$). Spatial sightings per unit effort analyses indicate that whales concentrate in different areas at different seasons. Preliminary photo-analysis indicates that at least 267 individuals have been identified, which represents >50% of the right whale population. Over the study period, 51% (137 whales) were sighted multiple times: 80 were resighted within a season (2-5 times) and 73 were sighted over multiple years (3-6 years). Adult males constituted the most common demographic group (40%), similar to the male-biased population sex ratio, and all age and sex classes were observed. In the winter and spring, examination of distance movements suggests that right whales were at northern [Gulf of Maine (GOM), Jeffreys Ledge, Cape Cod Bay (CCB)], and southern (Florida, Georgia) locations within months prior to visiting MVN. Several whales (4%) went back and forth between CCB and MVN, but most individuals were progressively spotted up north (GOM, Bay of Fundy, Gulf of Saint Lawrence) by summer. In the fall, they were first sighted at nearby locations (New York, Great South Channel, Jeffreys Ledge). These results coupled with observations of feeding, courtship, and calf presence, indicate that MVN is an important habitat. Our project outcomes will inform the spatial planning and construction of the offshore wind farm.

A cost-efficient standardised methodology for microplastics analysis: Case study of cetaceans and Mediterranean monk seals stranded on Samos Island coastline, Greece.

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The real impact of plastic pollution on the marine ecosystem is an issue yet to be fully assessed due to the lack of data and logistic difficulties, especially in remote locations. This study proposes a cost-efficient field methodology to be adopted as a model for microplastics quantification in sentinel species of the marine ecosystem.

A preliminary analysis of the presence of microplastics was conducted on a total of 12 dolphins (7 *Stenella coeruleoalba*, 4 *Delphinus delphis*, 1 *Tursiops truncatus*) and 3 Mediterranean Monk seals (*Monachus monachus*) found stranded

on the shores of Samos Island, Greece, between 2017 and 2019. Necropsies were conducted *in situ* or in the laboratory when possible. The entire digestive system was isolated from the oesophagus to the last tract of the large intestine. All samples were sieved (mesh sizes: 500µm and 200µm), treated to dissolve the organic matter content and filtrated through glass fibre filters. The slides were observed under x40 magnification to quantify and categorise the microplastic items into type (fibre; fragment), colour and size. A "hot needle test" was conducted to distinguish between plastic pieces and organic matter. A test for airborne contamination was performed at random.

A high concentration and variety of microplastics were found throughout each tract of the digestive systems of all the animals analysed, confirming the wide scope of the plastic pollution affecting the top predators of the trophic chain. These results prove the efficiency of the proposed field methodology to fill the data deficiency and improve the crucial research on marine litter impact.

The top-down effects of cetaceans in the Gulf of Mexico: Who are the key players?

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Due to their high historical and sometimes present-day abundances, capability for large-scale movements and high metabolic rates, cetaceans have the potential to affect the structure and function of ecosystems through a variety of mechanisms over both ecological and evolutionary time. Understanding top-down effects of cetaceans is important to assess their impact on communities and potential conflicts with fisheries. The Gulf of Mexico (GOM) is a large oligotrophic marine ecosystem with a high diversity of cetaceans (23 known species) that forage on a variety of commercially important species. An ecosystem model was constructed to evaluate the direct and indirect effect of cetaceans on GOM marine communities and fisheries. Seaward of the 1000 meters isobath, results suggest that top-down impacts are dependent upon the predator biomass, prey biomass, and importance of prey to the predator's diet. Due to their high abundance in the GOM and diet, cetaceans have a large, negative impact on juvenile stages of commercially important fishes (tunas and billfishes) through direct predation. Commercial fisheries target adult cohorts more than juveniles however there is competition for the small tunas (e.g., skipjack and Blackfin). We divided cetaceans present in the GOM, small (Delphininae) and large delphinids (Globicephalinae) and the deep-diving whales (e.g. beaked and sperm whales). Large delphinids have a negative impact on mesopelagic fishes, whereas small delphinids have an indirect, positive impact on mesopelagic zooplanktivores due to trophic cascade effects. Similar diets and the occasional predation of large delphinids on the small delphinids suggest that competition exists between these two groups. Comparatively, beaked and sperm whales do not have a significant impact on commercially important species but do negatively affect mesopelagic top predators like Dragonfishes. Ecosystem models will improve our understanding of each species ecological function and predict wider ecological consequences of potential declines or extinction of species.

Depredation mitigation device for pelagic longline fisheries: The PARADEP project.

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Depredation is defined as the damage or removal of fish or bait from fishing gear by predators. The long term objective of the PARADEP project is to reduce toothed whale depredation impacting pelagic longline fisheries targeting swordfish and tuna. This objective comes in three main components.

The **scientific** objective of PARADEP includes two sub-objectives. The first one is to develop a physical depredation mitigation device. This innovative device will have three protective skills: physical (barrier between the fish and the predator), visual (hiding of the fish) and passive acoustic (modification of the fish acoustic signature). Device trials will be held in Reunion Island (Indian Ocean) onboard commercial pelagic longliners. The second objective is to acoustically monitor the depredation process. Hydrophones, cameras and accelerometers will be deployed on the fishing gear along with the devices. This will allow to detect toothed whale presence, identify the involved species and analyze their acoustic behavior when they interact (or not) with the devices.

The **economic** objective of PARADEP will assess : i) the direct and indirect loss due to toothed whale depredation impacting the Reunion Island pelagic longline fishery, ii) the device position in the market of fisheries equipment, based on its estimated price.

The **communication** objective of PARADEP is to share the knowledge resulting from this approach to the public, political managers, stakeholders, scientists and fishermen. This will be done by the use of several communication supports, including the construction of a dedicated website (https://paradep.com) and the participation to various workshops, conferences and meetings.

PARADEP is funded by the European Funds for Maritime Affairs and Fisheries (FEAMP), and is due to last 30 months (July 2018 – December 2020). It involves three partners: two research labs (IRD MARBEC and CEBC CNRS) and one pelagic longline fishing company (ENEZ DU, based in Reunion Island).

What can acceleration tell us about the movements of an animal? An in-depth analysis of dolphin behavior.

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Obtaining detailed information about the behavior patterns of wild marine mammals has been a challenge over the years, and new techniques have been developed to automatically monitor movements. Accelerometry has shown serious potential in providing information about an animal's behavior; however, a validation of the behavior patterns is necessary. The goal of unsupervised classification is to be able to automatically identify the behavior performed by a dolphin without the requirement of video cameras. This validation is often impossible in the wild, so it is essential to do it in a controlled environment. For a data collection program involving two male adult captive dolphins (contexts: "alone" and "accompanied by other animal"), a total of 86 behaviors, grouped into 8 categories, were correctly classified by the algorithm: the Lateral Ascent, Lateral Swim, Lateral Dive, Inverted Dive, Glance Up, Dorsal Swim, Dorsal Dive and the Head Up. The most common behavior observed for both dolphins and contexts was Dorsal Swim. Sequence of behaviors were also analyzed and the results showed similar behavior sequences between both animals and both contexts, emphasizing that behavior patterns did not change because of this condition. An entropy analysis indicated that the dolphins' behavior contains a high-order structure that may allow the prediction, by a statistical model, of which behavior will follow a specific action. As far as we know, this is the first study building a behavioral map with the combination of the possible postures for a more complete behavior analysis. The unsupervised classification algorithm will make it possible to extract rare behavior patterns or those that researchers do not normally observe directly, including possibly anomalous behaviors. Even thought the algorithm is specific for bottlenose dolphins, it has the potential to be applied to other cetacean species and also other aquatic animals.

The evolution and diversification of delphinid skull shapes.

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The family of oceanic dolphins (Delphinidae) consists of approximately 36 species that occur over a range of aquatic habitats from rivers to the open ocean and in climates ranging from the Arctic to the Tropics. They are the result of an explosive radiation, with a rich diversity of species originating over a short window of time. Within these species, there is a remarkable variation of skull shapes, which has been hypothesized to reflect adaptations to feeding strategy, preferred prey and habitat, as well as sound production. In this study, we investigate the radiation of skull morphology of the 18 delphinid species occurring in the North Atlantic. We used geometric morphometrics to construct species-specific 3D models consisting of 51 landmarks, based on at least 3 specimens per species. We then mapped these models on a phylogenetic tree based on full mitogenome data using squared-change parsimony. In the most parsimonious model of skull shape evolution, the most recent common ancestor had a skull similar to Lagenorhynchus, Lagenodelphis, Leucopleurus or Tursiops. Early morphological diversification occurred in 3 directions: 1) towards more specialized raptorial feeding of small prey

with longer, narrower beaks, exemplified by Stenella and Delphinus species. 2) towards wider skulls with shorter, downward-oriented rostra and smaller temporal fossae, exemplified by suction feeders such as Globicephala, Grampus and Peponocephala. 3) Towards shorter and wider skulls with larger temporal fossae and anterior displacement of the orbit, exemplified by Orcinus. Under this model, the current delphinid diversity was established early on and the only major later development has been a convergence of the globicephalines Pseudorca and Feresa with Orcinus, apparently related to the handling of large prey items.The family of oceanic dolphins (Delphinidae) consists of approximately 36 species that occur over a range of aquatic habitats from rivers to the open ocean and in climates

Humpback whale site fidelity, group composition types, behaviors and habitat use in Guerrero, Southwest Pacific Mexico.

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In-depth marine mammal survey work has never been conducted before in Guerrero, SW Pacific Mexico and no official protection or monitoring measures are in place. We conjectured that humpback whales found off of Mainland Mexico include two distinct population segments, classified as threatened and endangered. In order to contribute to a clearer characterization of the North Pacific humpback whale population and generate conservation strategies, we conducted 1688 hours of boat-based surveys off of Guerrero (17.6417° N, 101.5517° W) between 2014–2018. We determined site fidelity and habitat use via photo identification, group type, location and acoustics and collected sloughed off skin samples for genetic analysis. Of 310 fluke IDs catalogued, 36 were resighted in Guerrero between 2014-2018. Intraannually, 21 individuals were seen more than once (2015(5), 2017(5) and 2018(11)) and interannually, 16 whales were resighted with encounters ranging from 345 to 1,103 days (mean:488d). There was an increasing number of sightings (n=638) along years, with effort time variation per encounter ranging from 6.86 and 1.38 h/sgt (mean:3.32). Solitary whales were the most frequent group type (LO:34.1%); followed by dyads (D:25.2%) and groups including calves (MC+:23.5%); the last two showed an inversely proportional relationship along years. Singing was detected 137/266 days (52%) that a hydrophone was deployed. Presence of competitive groups and singers, as well as mother/calf pair habitat use and behaviors suggests that this region is a calving and breeding ground.

In order to foster local stewardship, all data was collected in partnership with the fishing community and findings were publicly shared during weekly events and annual safe whale watch training programs. This approach resulted in the development of a successful community-led marine mammal monitoring and stranding network and effective coordination between tour guides. Federal recognition of the region as a whale watch zone is underway.

Decadal-scale changes in deep diving cetacean distribution in the central and North-East Atlantic.

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Major changes in the distribution of some baleen whales have been observed coincident with changing oceanography of the North Atlantic in the last 30 years. This study aimed to improve understanding of the underlying ecological drivers of any changes in deep-diving cetacean distribution. We used data from two series of summer surveys (in Iceland-Faroes and Norway) to model density of sperm, long-finned pilot and northern bottlenose whales as a function of static (relief), physical and biological oceanographic covariates using GAMs. The best models, based on a robust model selection framework, were used to predict distribution. The study period was divided into two periods, 1987-1989 and 1998-2015, based on environmental changes in the area and data availability. The common covariates that best explained these three species' distributions (in both periods) were relief variables and SST. The selected dynamic temperature-related covariates for sperm and pilot whales were for spring, but for bottlenose whales were for summer. Summer relationships were also found for the three species for the other dynamic variables, except spring chlorophyll-*a* for bottlenose whales. The difference in seasonal relationships for bottlenose whales may

be related to a previously suggested north-south summer migration. As expected, the predicted high-use areas for all three species were deep waters, with some overlap among them in the central Norwegian Sea, and the Central North Atlantic, including the Irminger Sea. Differences in distribution likely reflect differences in prey. Changes in distribution between the two periods appear more as a range expansion than a shift, with generally higher predicted densities in northern waters in recent years, which could result from an increase in suitable habitat due to warming waters. This new knowledge will help improve understanding of how these species may respond over this wide area to a changing environment and inform their conservation.

Field observations and Google Earth detections reveal mud ring feeding behaviors by bottlenose dolphins in Corozal Bay, Belize and Chetumal Bay, Mexico.

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Marine mammals sometimes evolve rare and complex feeding strategies involving learned behaviors adapted for targeting preferred prey in certain ecosystems. Rarely have the same complex tactics been detected in geographically distinct populations. Mud ring feeding is a behavior of bottlenose dolphins, reported only in Florida, USA, in which one dolphin kicks its flukes against the muddy bottom to create a circular mud plume to ensnare prey fish. Here we report evidence of mud ring feeding behaviors by coastal bottlenose dolphins in Corozal Bay, Belize and Chetumal Bay, Mexico documented from 2010–2019 during long-term monitoring of marine protected areas. Mud ring feeding events in Belize (n = 4) were directly observed from a small boat, plane, and drone, and inferred from aerial images of circular trails in the seafloor. Analysis of drone-based behavioral observations revealed that unlike dolphins in Florida, local dolphins created larger rings and spent more time hunting within and around the expanding mud plume. Visual searches for mud ring trails in satellite imagery covering both bays within Google Earth resulted in the detection of 94 trails and an instance of dolphins exiting mud plumes along the shores of Chetumal Bay in 2010. Size comparisons of mud rings and plumes imaged from the drone with remotely-sensed ring trails confirmed their similarity. The distance between our study site and Florida (ca. 1,100 km) and the millennia since these populations diverged suggests dolphins in these shallow muddy habitats independently innovated the creation of mud rings and converged on a similar feeding specialization. These findings illustrate dolphins are capable of converging upon the creation of complex objects to facilitate feeding, and stimulates the need for further study to investigate the prevalence of this tactic in the Caribbean Sea and its implications for the management of local dolphin populations.

Perception bias: How aerial imagery revealed underrated threat of entanglement in large rorquals.

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Entanglement in fishing gear is a known threat to all cetaceans, pushing some species, like the vaquita and North Atlantic right whale, towards extinction. For large rorqual species, such as blue and fin whales, entanglement reports are relatively rare, leading to the presumption that entanglement is less common in these species. The known high proportion (60-80%) of previously entangled North Atlantic right and humpback whales is based on surviving animals bearing scars from fishing gear. The most prominent scarring is found around the tail and peduncle, visible when animals lift their tails before diving. Given that fin and blue whales are rarely fluking, entanglement rates have likely been underestimated. We used a drone equipped with a high-resolution camera to obtain aerial footage of individual blue and fin whales in the Gulf of St. Lawrence, allowing us to identify individuals and investigate the body for scars indicative of prior entanglements. We graded pictures based on angle, light, focus, resolution,

and body part. Three researchers independently examined the pictures and recorded scarring marks. We identified 91 individual fin whales based on pigmentation patterns. Of the individuals with good or excellent images (n=35), 42% had scars from previous entanglements, compared to 53% for individuals with excellent pictures only (n=17). The scarring occurred always around the peduncle, often the tail, rarely the dorsal and never around the flippers. Some images suggested that the focal entanglement point was the mouth, and scaring further along the body may have partly resulted from trailing gear. Thus, some scars may have gone undetected, and we regard our estimate as a minimum. The single sampled blue whale was matched to the existing catalogue and had a laceration on the peduncle. In conclusion, aerial imagery is the preferred method to quantify scarring rates in species which do not fluke frequently.

Beaker BANTER: A machine learning approach to acoustic classification of beaked whales.

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Passive acoustic methods have proven to be effective for monitoring beaked whales; however, classifying beaked whale acoustic detections to species can be difficult for large datasets with multiple beaked whale species. Manual classification of acoustic data requires significant time investment by highly trained technicians and is difficult to reproduce. Here we develop and test a novel approach to beaked whale acoustic classification. BANTER is a newly developed machine learning approach to acoustic event classification that utilizes information from multiple rather than single call types (e.g. dolphin whistles, clicks and burst pulses). BANTER performs stably and yields a high rate of correct classification when applied to dolphins. Its conceptual framework easily lends itself to other species, study areas, and taxa. In an effort to apply this compound classification scheme to events consisting solely of click detections, we developed a series of alternative detectors, measurements and call classifiers to allow for BANTER acoustic classification of beaked whale species. Multiple click detectors were developed within Pamguard and applied to beaked whales detected on drifting recorders (US West Coast, Hawaii) and towed arrays (US Atlantic Coast and Gulf of Mexico). Measurement of spectral peaks/notches as well as measures derived from Wigner-Ville plots provide additional measurements for call classification. For overall event classification, BANTER considers results from these multiple call classification results. Correct classification scores for 917 beaked whale events detected in the US west coast (comprised of five putative beaked whale species) ranged from 89% to 100%. BANTER provides systematic and reproducible results in minutes. Also, BANTER's systematic approach combined with its tools to estimate model performance can be used to inform potential geographic variation. These results will be used to further develop a series of open-source software packages to facilitate BANTER event classification for data analyzed in Pamguard.

A calorific map of harbour porpoise prey in the North Sea

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The distribution of harbour porpoises (*Phocoena phocoena*) is thought to be prey driven but our understanding of prey availability is currently limited. Harbour porpoises have restricted energy storage, and high foraging and metabolic rates. Energy balance is therefore crucial to our understanding of porpoise ecology, including caloric content of prey. This project provides a first attempt to describe the spatiotemporal variation in energy available from different prey species to porpoises in the North Sea.

Energy maps were produced for Atlantic cod, Atlantic herring, European sprat, sandeels and

whiting, for the most recent two years that North Sea-wide cetacean surveys were carried out (2005 and 2016). A cleaned dataset of the International Bottom Trawl Survey was used. Relative gear efficiency factors per prey species and size class were used to correct for catchability. Biomass values were converted to energetic content using published energy density values. These energetic content estimates were used to create density surface models using Generalised Additive Models with soap filters to avoid smoothing across boundary features.

Overall mean estimates of total energy available from the modelled species in the North Sea ranged between 21,610 (winter) megajoule (MJ) per km^2 in 2005 and 76,938 MJ per km^2 (summer) in 2016. Large amounts of prey energy were predicted with consistent high contributions from sandeels and whiting. Sprat and herring added considerably to the overall energy dependant on the season. Wild harbour porpoise daily energy requirements vary between 9-31 MJ. This suggests that even within "low" energy areas there would be sufficient energy to sustain porpoises if this energy was available to them. However, the energy predicted may not correspond to the actual available energy for porpoises given the role of other marine predators and the fishing industry present in the North Sea, prey patchiness, and 3D distribution of prey.

Humpback whale (Megaptera novaeangliae) spatial ecology and the risk of vessel strike in a Mexican breeding area facing extensive coastal modification

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The mainland Mexico state of Nayarit is an important breeding/calving area for the 'Threatened' Mexican humpback whale population and acts as a migratory corridor to the 'Endangered' Central American humpback whale population. However, knowledge of the species' seasonal distribution and habitat use throughout the state is limited. Without a major container port, and it's geographic location sheltered by the Baja California peninsula, Nayarit was previously one of the only Mexican Pacific states not to receive heavy shipping. In the last five years, several large port developments have been proposed in the region, whilst maritime traffic is already increasing due to rapid tourism growth and coastal development. Vessel strike is the major modern global threat for large whales, particularly for small or endangered populations. Humpback whales are one of the most commonly hit species, and a significant proportion of the Mexican population bare propeller scarring, suggesting that vessel strike is already an issue. To characterize the distribution, composition and movement of whales, we conducted aerial and vessel surveys during two humpback whale breeding seasons (2018 and 2019) in coastal Nayarit. We identified high humpback whale site fidelity to Nayarit, long residency times within breeding seasons (over a month for some mother-calf dyads), and found strong migratory connections with Central American breeding areas. Humpback whale distribution models suggested differences in habitat use of migrating and breeding/calving activities, and identified critical areas of humpback whale habitat. Using the distribution models with AIS shipping data we quantified the risk of vessel strike in this region, identifying areas of current and projected risk based on planned developments. Our results allow for effective planning of port developments through the spatial assessment of the placement of shipping lanes to minimize vessel strike and the establishment of a Marine Protected Area to regulate commercial shipping and marine tourism.

Swimming dynamics of humpback whale (Megaptera novaeangliae) calves accompanied by their mother.

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A study of the swimming dynamics of humpback whale (*Megaptera novaeangliae*) calves accompanied by their mother was conducted in the Sainte Marie channel (Madagascar). Our knowledge on such topic is quite limited and thus we aimed to prove the existence of specific swimming configuration offering energetic advantages for calf in mother-calf dyad, and to compare mother-calf swimming behavior. Through kinematic analysis, opportunistic underwater video clips of travelling mother-calf dyads were used to investigate the variation of calf's relative swimming effort (tailbeat frequency based parameter) according to the swimming configuration. Dive profiles collected using multi-sensor tags were used to compare the swimming control and stability. Analysis of 21 short video clips extracted from 4.5 hours of videotapes showed that calves swim mainly in echelon (close to its mother's mid-lateral flank) to save energy evidenced by a 23.5% reduction of swimming effort, and they also show a right-biased lateralized behavior. Analysis of 129 dive profiles from three tagged dyads showed that calves' active swimming behavior is much less elaborated compared to those of their mothers but the gliding is already fairly controlled. These findings highlight the importance of the proximity between mothers and their offspring and the necessity of strict regulations for their observations in order to minimize the risks of mother-young separation.

Pinniped entanglement response best practices.

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Pinniped entanglement in marine debris and fishing gear is a global issue of increasing concern. With the growing number of entangled pinnipeds worldwide comes a greater need for protocols to safely respond to these animals. There are many different entanglement response methods employed to respond to entangled pinnipeds including physical restraint on land (herding boards, nets, etc.), physical restraint in the water (tangle nets, hoop nets, purse seine, etc.), non-remote (hand inject) sedation, and remote (i.e., dart projector) sedation. However, there are currently no standardized best practices for pinniped entanglement response. Therefore, the National Marine Fisheries Service sought to incorporate the most successful techniques used by responders in various geographic regions into one national Best Practices document. First, we developed a questionnaire asking marine mammal stranding network members and Pinniped Entanglement Group members for their own best practice documents, training manuals, and entanglement response forms and reports. We then summarized all existing protocols into one overarching National Pinniped Entanglement Response Best Practices document. This document covers best practices for preparing for an entanglement response, procedures, equipment, and drugs used during a response, assessing risk and mitigation, and identifying future research needs. Examples of best practices include: making human and animal safety a top priority; using a decision matrix and incident command system to assess and minimize risks to animals and responders; ensuring responders are well-qualified; clearly defining team roles and responsibilities; and continuing to adapt and search for better capture tools and techniques for maximizing safety. Once this Best Practices document is finalized, it will be available to pinniped entanglement responders worldwide to enable knowledge sharing and collaboration as we seek to continually improve our entanglement response techniques.

Protozoal agents infecting tissues from hunter harvested beluga (Delphinapterus leucas) in the Beaufort and Bering Seas

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The extent to which protozoan parasites infect arctic populations of hunter harvested Beluga is unknown. These marine mammals are a source of nutrition for first nation peoples in the Western Canadian Arctic and Alaska, highlighting the importance of determining whether zoonotic protozoan parasites infect these populations. Two populations of Beluga from the Beaufort Sea

(n=48) or Bering Sea (n=28) sampled between 2008-2018 were assessed for protozoal infection using PCR-DNA sequencing. The genetic analyses identified two protozoal agents. A new species, *Sarcocystis monodontidis*, was detected in 36/76 (47%) animals. *S. monodontidis* was statistically more prevalent in Beaufort Sea Beluga than Bering Sea Beluga (65% vs. 18%; p=0.00011, two-sided Fisher's Exact test). *Toxoplasma gondii,* a prevalent zoonoses, infected 9/76 (12%) whales and was equally represented between the two whale stocks. Whales infected with *S. monodontidis* possessed light to heavy infections with individual sarcocysts noted within striated muscles of the tongue, esophagus, and diaphragm, as well as skeletal muscle fibers throughout the torso. No inflammation was associated with intact cysts. *Toxoplasma* parasites were detected in the heart and diaphragm of infected whales and immunohistochemical staining confirmed the presence of *Toxoplasma* cysts in the heart of one whale, establishing the presence of transmissible forms of the parasite. Multilocus genotyping of *T. gondii* infected whales identified two, previously uncharacterized, recombinant strains. This is the first study to genetically characterize chronic *T. gondii* infections in healthy, free-ranging Beluga with no associated histopathology of active toxoplasmosis. These whales are wide ranging and the source(s) of parasite exposure have not been identified. However, detection of novel, recombinant strains of *T. gondii* infecting Beluga may indicate the definitive felid host is expanding this parasite in the Arctic, since Beluga are not carnivorous, and were likely infected by ingestion of *T. gondii* oocysts, products of the parasite's sexual cycle.

Diversity and distribution of marine mammals over the submarine canyons off Otago, New Zealand.

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Submarine canyons are hotspots of productivity in the deep sea, and important habitat for top predators. Canyons potentially concentrate mid-trophic level prey providing enhanced foraging opportunities for deep-diving marine mammals, but this relationship has rarely been tested. The continental shelf off Otago, New Zealand, is incised by a network of canyons which to date have been poorly studied. To investigate diversity and distribution of marine mammals, we conducted visual line-transect and passive acoustic surveys off the Otago coast between 2016 and 2019, in depths from 50 to 1300 m. For a subset of the surveys we recorded water-column acoustic backscatter (assumed to be a proxy for mid-trophic level biomass) with a 38 kHz scientific echosounder sampling concurrently with the visual survey. In all we completed 886 km of survey effort over 15 days, of which 272 km had associated backscatter data. We recorded 64 cetacean encounters representing nine species, and 217 sightings of New Zealand fur seals. The most frequently sighted cetaceans were dusky dolphin (n=27 encounters), sperm whale (n=10), and long-finned pilot whale (n=9). The poorly known Shepherd's beaked whale was seen on four separate occasions. Acoustic detections of sperm whales were made in every season, suggesting year-round presence of the species in deep water habitat in this region. Counts of fur seals per 1km survey segment were related to bathymetric and oceanographic variables and potential prey abundance via generalised additive models. The best model (32% deviance explained) indicated a negative relationship with distance to the coastline, and positive relationships with SST gradient and epipelagic and mesopelagic backscatter. Our results suggest that submarine canyons modify the availability of pelagic biomass and hence influence the distribution of marine mammals, reiterating the importance of these keystone features at a time when the human footprint on deep sea ecosystems is rapidly expanding.

The economics of extinction: The illegal totoaba fishery and the impending loss of the vaquita.

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The imminent extinction of the vaquita is being driven by bycatch in an illegal gillnet fishery for the totoaba, a large endangered drum. Dried totoaba swim bladders (*buches*) are smuggled to China where they can be sold on the black market for more than $20,000 USD per kg. We examine this case study in the context of general economic theories of rational choice, which posit that participation in an illegal activity (the totoaba fishery) will be favoured if: the revenue gained from illegal fishing outweighs that from legal fishing; the chance of being apprehended is small; and the cost of punishment is low. In this case, the

totoaba fishery is extremely lucrative (fishermen can sell *buches* for $5,000 USD per kg) and poachers face a low probability of being apprehended and prosecuted, so there are strong incentives to enter the fishery. An important factor contributing to the rapid development of the totoaba fishery was the existence of organized crime cartels, which adapted their existing trafficking networks to exploit the market for *buches*. In addition, a complete ban on gillnet fishing in the Upper Gulf may have exacerbated the crisis, as a government funding program designed to compensate fishing communities was poorly administered. Many fishermen received little or no compensation, further favouring their participation in the totoaba fishery. Finally, enforcement efforts were undermined by corruption, resulting in few arrests and fewer prosecutions. Thus, despite the investment of more than $100 million USD and political support from the highest levels of the Government of Mexico, the vaquita will go extinct. Seen through this economic lens, perhaps the demise of the vaquita was unavoidable. Nevertheless, there are important lessons to be learned for other endangered cetaceans, such as the Yangtze finless porpoise and Mekong dolphin, which are also threatened by illegal fisheries.

Depredation by coastal bottlenose dolphins (Tursiops truncatus) in the Southwestern Gulf of Mexico in relation to fishing techniques

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Cetacean–fishery interactions are a recurring problem. These interactions are conflict prone, especially between fishers and those seeking marine mammal conservation. In the southwestern Gulf of Mexico, a large fleet of artisanal fisheries operates using a range of different techniques. We recorded 90 fishing operations in two different fishing areas of Veracruz, Mexico, between 2009-2010 and 2014-2015, assessing whether dolphin interactions negatively affects fish catch and fish gear. These potential impacts were using three generalized linear models (GLMs) hypothesizing that (1) depredation decreases catch per unit effort (CPUE), (2) the predator presence modifies catch composition, and (3) prey species presence increases the likelihood of depredation. Of the gillnet hauls analyzed, 27 were subject to depredation by bottlenose dolphins, despite conditions and fishing methods varying among sites. Higher CPUE attracts larger pods, but a negative effect by depredation was not detected. We also found that depredation probability increased when there were higher capture volumes, when mackerels and jacks were present, and when operations were most southwesterly. Despite the short distance (< 80 km) between sites, we found that bottlenose dolphins on each site displayed different feeding behaviors towards fishing nets. Regarding conservation, bycatch caused by dolphins does not seem to be problematic. In fact, the increase in boat traffic and declining prey abundances due to overfishing could be the main causes of fishers' economic loss. Dolphin–fishery interactions may not represent an actual challenge for marine conservation managers, but stakeholders, fisheries, and governmental institutions should be aware that diminishing returns due to overfishing could exacerbate the apparently false notion of dolphins competing for the fish.

Developing minimally invasive diagnostic methods for monitoring lungworm infections and cortisol in harbour porpoises (Phocoena phocoena)

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Harbour porpoises are the most abundant cetaceans in the North and Baltic Seas. Lungworm infections (Metastrongyloidea, Pseudaliidae) are the most health impacting parasitic infections of porpoises in those waters. They are regularly associated with secondary bacterial infections causing severe bronchopneumonia, often resulting in the animal's death. Additionally, effects of anthropogenic activities have the potential to cause chronic stress and may contribute to severe pulmonary infections.

Since exhaled breath (blow) sampling has been successfully established for hormone evaluations in large whales, the best tools to effectively collect blow samples and the necessary amount of exhales for an evaluable harbour porpoise sample were identified. Three different collection methods were tested and a simple Falcon 50mL Conical Centrifuge Tube was identified as most suited device. Since the amount of exhaled tissue is minimal (< 1 µl), the analyses had to be limited to one steroid hormone, and cortisol was chosen as first parameter. The next steps are to correlate blow cortisol levels with blood samples to evaluate if blow is a suitable matrix for non-invasive stress monitoring in porpoises.

For the detection of lung nematode antibodies in blood samples, serological tests were performed on blood from stranded carcasses and individuals in rehabilitation. The samples were grouped into positive (infection proven through necropsy or bronchoscopy) and negative (animals born in human care) clusters. Blood from animals in long-term human care was additionally evaluated for changes in antibody persistence over time. Since an ELISA with HRP-conjugated Protein A as secondary antibody was not able to discriminate between positive and negative samples, western blots are currently evaluated for their suitability as diagnostic tool.

These diagnostic tests can become important tools to monitor antibodies against lungworms as well as stress levels in free-living and rehabilitated harbour porpoises and help to further understand harbour porpoise population health.

Vocal imitation in a Grey seals pup

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Vocal imitation is the ability to learn a previously unknown sound by imitating an acoustic model. This process allows individuals to rapidly acquire new communicative signals and comparative studies are useful to clarify the mechanism that enable plasticity in sound production and usage in different species. Pinnipeds share characteristics, such as the capability to produce a broad variety of vocalizations and a high degree of control over the supra-laryngeal part of the vocal tract, that support the ability to acquire new sounds. Specifically, grey seals (*Halychoerus grypus*) breed in high density colonies, where pups vocalise repeatedly to attract their mothers' attention. We studied Grey seals pups with an age-range of 5-30 days, during their rehabilitation period at the Sealcentre Pieterburen. We analysed the acoustic features of each animal and then selected a model call of an individual from the previous year that showed completely different acoustic characteristics. We presented a playback to a group of 5 grey seals pups and we recorded their vocal reaction. This 'novel' playback was played to the focal animals for 28 days, 30 minutes a day, while recording them. One individual of the group started to imitate the model and therefore to change its vocal features. We analysed the distribution of the acoustic frequencies based on temporal parameters for this animal before and after the experiment, the model and the other member of the group. Preliminary results show an increased acoustic similarity between this seal after the experiment and the model, compared to the same animal before the experiment and the other seals of the group. Overall, our study suggests that grey seals pups can spontaneously produce sounds outside their original repertoire through the imitation of a model and may therefore be capable of vocal production learning.

Productive harmony: Offshore wind and marine mammals.

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At least 65 species of marine mammals occur in the offshore waters of the USA. Currently, twenty-nine US States, Washington, D.C. and three territories have adopted renewable portfolio standards to diversify their energy resources, promote domestic energy production and encourage economic development. As of April 2019, the Bureau of Ocean Energy Management (BOEM), under the Department of Interior, oversees 15 commercial wind energy leases in the Atlantic and industry interest in California and Hawai'i is increasing. BOEM's mission, in part, is to ensure that these activities are done in an environmentally responsible way. During the first two years of area identification (i.e. planning and analysis), BOEM's subject matter experts study potential offshore wind energy sites to identify areas of environmental sensitivity/importance, and develop lease areas appropriately. After a lease is issued, leaseholders

conduct surveys to characterize the site and assess the wind resource. BOEM works closely with lessees to ensure the necessary environmental data is provided, and/or collected, to support plan submissions. BOEM requires this data to assess the potential impacts to protected species from the proposed activities. BOEM's renewable energy authorization process includes approximately 8 years to assess and/or collect environmental and protected species data before any construction plan is reviewed. BOEM's Environmental Studies Program (ESP) solicits study ideas from the public on an annual basis. The ESP provides funding to other Federal agencies, academic institutions and researchers to design and execute studies to address these data gaps, including sound impacts to marine mammals, marine mammal distribution and habitat use, entanglement and vessel strike risks from all BOEM-related activities. In addition, BOEM uses the results of these studies to inform mitigation strategies, including protected species observers, monitoring and exclusion zones, vessel speed restrictions, sound source verification and noise reduction technology.

Population genomics of killer whales (Orcinus orca) in Australia.

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Population genomic datasets have great power to detect cryptic and complex population structure and can generate information to address real-world issues in conservation and management of marine fauna. Killer whales (*Orcinus orca*) have highly complex population structure worldwide, and are currently assigned as data deficient by the IUCN. In Australia, there is limited information currently available about their population structure, but two regions with high seasonal use have been recently discovered: one located mostly inshore in Ningaloo Reef, north-western Australia (NWA), and the other offshore in the Bremer sub-basin, off south-western Australia (SWA). There is little knowledge about their feeding strategies in these regions, but observations suggest they prey upon multiple cetacean species, various fish species, including sharks, and cephalopods. Here, we present a population genomic assessment of killer whales from these two Australian regions. This was accomplished by using a genome-wide dataset of 9,035 high quality single nucleotide polymorphism (SNPs), and sequences of the mitochondrial DNA (mtDNA) control region. The results indicate that killer whales from these two regions represent genetically distinct populations, with low contemporary migration between them, and negligible levels of inbreeding within each population. Genomic estimates of effective population size using a linkage disequilibrium method resulted in 11 (95% CI 3-62.6) individuals for NWA, and 39 (95% CI 24.6-78.1) individuals for SWA. Analysis of mtDNA revealed only two haplotypes; one was predominantly found in SWA and the other in NWA. These results are consistent with studies of killer whale populations from other oceanic regions that showed low haplotypic diversity and high female philopatry. Additional SNP data to be generated from other Australian and New Zealand samples will be used to further clarify demographic parameters of relevance for conservation management of killer whales in the Australasian region.

Underwater hearing and communication in the endangered Hawaiian monk seal (Neomonachus schauinslandi)

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Monk seals are among the most endangered marine mammals, and the most primitive phocid seals. We lack substantive bioacoustic information for monk seals, with no formal descriptions of underwater vocalizations and limited data concerning their ability to hear underwater sounds. The auditory biology of monk seals is compelling from behavioral, conservation, and evolutionary perspectives. These seals have been isolated for more than 10 million years, and have auditory structures that differ from those of other living species. Unlike other aquatically mating phocids, monk seals breed asynchronously and are not known to produce social calls in water. To address

knowledge gaps, we thoroughly evaluated a single captive individual. A mature male Hawaiian monk seal was trained to perform a psychophysical task while submerged. Sound detection thresholds were measured for narrowband tones across the frequency range of hearing. Additionally, an acoustic recorder was placed in the seal's living enclosure, enabling characterization of spontaneous vocalizations and seasonal trends in calling. We found this individual to have best hearing from 1 to 25 kHz, with reduced high-frequency hearing relative to other species. In contrast to an early report, this seal could readily detect low-frequency sounds, however hearing at all frequencies was less sensitive than in other true seals. Despite the absence of conspecifics, the seal regularly produced at least six different underwater calls with spectral energy below 1 kHz. Seasonal calling patterns reflected a period of reproductive activity lasting more than seven months, coincident with elevated testosterone levels and increased production of all call types. This study presents the first examination of underwater vocalizations in Hawaiian monk seals, provides insight into the perceptual abilities of this species and the evolution of underwater hearing within the phocid lineage, and enables improved assessments of noise effects on these vulnerable seals. [Supported by US Navy's LMR Program].

Four-flippered dolphin: A new interpretation of hind flipper evolution.

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It is rare for hind flippers to develop in cetaceans, but their presence provides important insights into cetacean limb evolution from a tetrapod ancestor. An opportunity to study this occurred when a four-flippered, adult female, bottlenose dolphin (*Tursiops truncatus*) was discovered and captured off the coast of Japan. This study examines reconstructed images derived from her whole body CT scans.

The hind flippers are falcate-shaped, and supported by several bones. The right hind flipper is larger than the left. The most proximal bone lies adjacent to the pelvis and is identified as a femur in both flippers. The bones immediately distal are identified as the tibia (right only), and fibula (both flippers). The next set of distal bones determines the number of digital rays. The right flipper has three tarsals (calcaneus, tarsal, astragalus/talus) and three metatarsals (small, medium, large), while the left flipper has only two tarsals (calcaneus, tarsal) and two metatarsals (small, large). Four phalanges, gradually diminishing in size from proximal to distal, are aligned in one long digit extending to the caudal tip of each hind flipper. An additional single phalanx is found on the leading edge of the right hind flipper, immediately distal to the medium metatarsal.

Digit reduction in this dolphin is not surprising, as fossil whales had four (*Ambulocetus*, *Rodhocetus*) or three (*Dorudon*, *Basilosaurus*) hind digits. The common cetartiodactyl ancestor likely exhibited reduction from five digits, as modern descendants have four digits (hippopotami) or two digits (artiodactyls). Digit loss and limb shortening eventually led to hind limb disappearance during cetacean evolution. The re-appearance of hind extremities is an atavistic trait that harks back to tetrapod ancestry. The falcate-shape of this dolphin's hind extremities suggests an evolutionary path from archaeocete hind limbs, to an undiscovered recent ancestor with hind flippers, before hind appendages disappeared altogether in modern cetaceans.

Mapping prey fields of foraging humpback whales in British Columbia, Canada.

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Effective conservation of whale and fish populations requires an understanding of trophic ecology that is difficult to obtain without concurrent acquisition of prey data and whale foraging observations. Developing a cost-effective sampling framework for obtaining time-series data on prey composition and spatiotemporal dynamics of baleen whale feeding remains a major challenge. We investigated a sampling method that measured a variety of surface and deep-water prey characteristics in North Pacific Humpback Whale feeding areas near northern and southern Vancouver Island, British Columbia (B.C.), Canada. The vertical distribution of prey was continuously recorded near feeding Humpback Whales from a small vessel using an Acoustic

Zooplankton and Fish Profiler (AZFP), following fine-scale transects to map three-dimensional prey fields. The surveys were conducted in daylight hours in regions with and without foraging Humpback Whales to describe prey in the areas used by the whales. Regional mid-water prey sampling informed the species composition of acoustic signal data, while humpback fecal sampling provided information about which prey species were actually consumed. Results showed consistent differences between feeding regions, with Humpback Whales targeting shallow Pacific Herring aggregations off northern Vancouver Island but deep layers of Walleye Pollock and euphausiids in southern Vancouver Island waters. Fecal samples from surveyed whales in southern waters comprised mainly bones from juvenile Walleye Pollock or Pacific Cod, while surface observations documented juvenile herring as the dominant humpback prey in northern waters, thus linking Humpback Whale foraging to concurrent measures of prey from the AZFP. Given the current lack of knowledge about Humpback Whale diet and the whales' impact on forage fish in B.C., this combined approach provides a framework for intensive baseline sampling that is needed for accurately estimating diet and regional prey requirements of Humpback Whales at the level required for making important fisheries decisions.

Applying novel methods to uncover the source rookery of Little Penguins predated by Long-Nosed Fur Seals

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In South Australia, Long-Nosed Fur Seal (LNFS) *Arctocephalus forsteri* pup production has increased by more than 3.5 times since the 1980's. Little Penguins *Eudyptula minor* are a component of LNFS diet that is not well understood and LNFS breeding distribution is continuing to expand as the species recolonises their former range. Across southern Australia, a number of significant Little Penguin declines have been recorded and developing a better understanding of LNFS and Little Penguin predator-prey dynamics has been identified as a key priority. This research tests the use of Trace Element Analysis (TEA) and Stable Isotope Analysis (SIA) to identify the source rookery of Little Penguins predated by LNFSs. Feathers are the only consistent remain recovered from predated Little Penguins in LNFS scats. Once grown, feathers are metabolically inert and store stable isotope compositions and toxicological information that reflect the diet during the pre-moult phase. In this study moulted Little penguin feathers from 16 breeding sites (~22 burrows per site) were sampled to map feather 'fingerprints' for comparison with feathers recovered in scats from 15 LNFS sites (15-50 scats per site). The contribution of Little Penguins to LNFS diet varied between sites with feathers present in 0-40% of scats. This study found that nitrogen (δ15N) and carbon (δ13C) isotopes were effective at distinguishing sites at a regional scale, when combined with trace element signatures; Aluminium, Zinc and Iron, the highest site/regional resolution was achieved and in some instances site-specific signatures detected. Captive LNFS feeding trials confirmed that feather digestion did not compromise Stable Isotope and Trace Element signatures generated. Combined, SIA and TEA provide a novel approach to exploring complex marine predator-prey relationships, information on sites with high trace element loads and new insights into ecological shifts from top predator populations re-entering an anthropogenically altered marine environment

Marine mammal tracking to define ecological hotspots in the extended Southern Ocean: Perspectives from the Retrospective Analysis of Antarctic Tracking Data (RAATD) project.

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Data on the movements of marine predators are increasingly used in multispecies synthesis studies to identify ecologically important areas at sea. The rationale is that areas that are important for several predator species are places that support high abundance and diversity of lower trophic level species and thus have high ecological importance.

In the Retrospective Analysis of Antarctic Tracking Data project, we synthesized tracking data for 17 marine predator species of the extended Southern Ocean (circumpolar oceans south of 40˚S). The dataset includes >4000 tracks and nearly 3 million location estimates.

We fitted habitat selection models for each species and then combined their circumpolar predictions to identify regions of common importance. Regions with the highest mean habitat importance represent Areas of Ecological Significance. These were located around the Antarctic continental shelf and in two more northerly aggregations: one in the south-west Atlantic, encompassing much of the Scotia Sea and surrounding waters, and the second covering the chain of Subantarctic islands from the Prince Edward Islands through to Heard and McDonald Islands and parts of the Kerguelen Plateau.

The dataset includes tracking data for five marine mammal species: Antarctic fur seals, crabeater seals, southern elephant seals, Weddell seals and humpback whales. We present our circumpolar predictions of habitat importance for these species and discuss them with respect to predictions for the full suite of species.

Based on our predictions, we offer perspectives on spatial management and conservation.

Our synthesis had spatial and taxonomic data gaps that should be filled in the future. We are uncertain about the importance of ocean regions that are accessible to few land-based central-place foragers, such as the south Pacific Ocean, and we should collate available tracking data for more cetacean species. We encourage the marine mammal research community to fill these gaps through continued large-scale synthetic, collaborative research efforts.

A review of the current evidence on the classification of North Atlantic killer whales (Orcinus orca) as distinct ecotypes.

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Killer whales are top predators known to feed on a wide range of prey species, including fish and marine mammals. In some regions, killer whale dietary specialization warrants, along with supporting movement, behavior, morphological and/or genetic differentiation, classification of subpopulations as separate ecotypes. Two ecotypes have been proposed in the North Atlantic based on limited and largely observational data, but remain unconfirmed. The existence of a North Atlantic generalist, which feeds on fish and occasionally on marine mammals, and a North Atlantic specialist, which feeds on marine mammals, have been proposed. The goal of this review is to evaluate existing evidence for the occurrence of North Atlantic ecotypes and to identify key data gaps required to clarify this question. Data acquisition is complicated because the observation of killer whales foraging in the wild is only occasional, often seasonal and may not accurately reflect the long-term diet of a population. Likewise, data on stomach contents is scarce and only available in necropsy cases. Thus, non-lethal, time-integrated chemical tracers have been applied to assess the diets of killer whales in the North Atlantic Ocean. Stable isotopes have shown that Norwegian and Icelandic whales rely on herring. However, the data resolution was low and could not clearly delineate groups. Therefore and to our knowledge, confirmation of specific ecotypes based on feeding differences remains elusive. Other dietary tracer approaches, some of which have been employed to

successfully identify North Pacific killer whale ecotypes, include comparisons of concentrations of biomagnifying pollutants, blubber fatty acid signatures, and compound-specific isotopes analysis. Ecotypes delineated based on feeding ecology could face differences in risks posed by climate-driven changes in prey availability and by exposures to environmental contaminants. Thus, improved conservation strategies should include renewed efforts to resolve the question of the existence of multiple North Atlantic killer whale ecotypes.

Inter-governmental framework for tackling cetacean bycatch

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Accidental entanglement in fishing gear is generally considered the most serious threat to cetacean populations, as well as many other marine species. Addressing it requires effective collaboration between the environment and fishing sectors, a challenge that conservationists have been grappling with for decades. Using the example of the UN Agreement on the Conservation on Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the poster outlines the collaborative framework set up to combat bycatch and key aspects of the guidance given and work underway. In particular, this includes Resolutions for guiding member countries in how to address bycatch; action plans and regional groups to help stakeholders implement measures in a coordinated fashion; and workshops in order to understand issues better and to develop guidance. ASCOBANS and ACCOBAMS, the Mediterranean and Black Seas sister agreement to ASCOBANS, have established a joint working group on bycatch., which addresses their respective mandates. In providing its advice, the working group will liaise as necessary with other relevant bodies and fora, including working groups of the two Agreements, the ICES Working Group on Bycatch of Protected Species, the IWC bycatch initiative, Regional Seas Fishery Management bodies, RFMOs and NGOs active in the field. The Convention on Migratory Species (CMS), under which ASCOBANS was concluded, also gives bycatch a high priority. The Conference of the Parties has passed a number of resolutions on the subject. The CMS Scientific Council has an Appointed Councillor for Bycatch, who not only provides expert advice on the matter but also takes the lead in liaison with RFMOs and the monitoring of relevant research and technological developments. This poster will showcase the framework provided by the ASCOBANS and ACCOBAMS Secretariats for countries to combat bycatch in their waters and on the high seas.

Who's talking? The challenges of bioacoustics research in captive manatees in Mexico.

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The vocal repertoire of Antillean manatees in Mexico and their association with different behaviors is largely unknown. We sought to identify and categorize the vocal repertoire of a captive population of manatees (7 females, 11 males) at the facilities of Dolphin Discovery in Quintana Roo, Mexico. The animals were held in groups of seven (Puerto Aventuras), three (Dreams), four (Cozumel) and four (Isla Mujeres) individuals per aquarium. We conducted 40 minute recordings per manatee, and 40 minutes per group when individual isolation was impossible. The recordings were collected in WAV format with an SQ26-08 hydrophone and Tascam DR05 digital recorder resulting in 408 minutes of acoustic recordings. Recordings were samples in 5-minute intervals and analyzed in spectrograms with Raven acoustical analysis software. We measured the maximum frequency, minimum frequency, and duration of calls. During the spectra analysis, the main challenge consisted in isolating manatee vocalizations, since dolphin vocalizations, anthropogenic sounds (boat propellers, aerial drone), and other environmental noise masked the sounds emitted by manatees. The noise frequency evidenced in the aquariums oscillated between 1600.0–8123.1 Hz, whereas the frequency of manatee vocalizations ranged between 3730.8–5561.8Hz, and 0.1 to 0.5 s. Vocal production rate was highest (3.53 vocalizations per 30 min) in groups of three or more manatees during socializing. We identified numerous recognized acoustic categories including tonal sounds with varying structures (e.g., increasing, decreasing, U-Shaped, complex modulation). To our knowledge, this is the first attempt to study the vocal behavior of Antillean manatees in the Mexican Caribbean.

Potential impacts of vessel noise on Commerson´s dolphins in Patagonia Argentina
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Anthropogenic noise is a source of pollution in many coastal areas and can potentially affect marine species. Some of the impacts include reduction in range over which individuals can effectively receive acoustic signals, alteration of sound properties, among others. This study quantifies increases in ambient noise levels produced by individual vessels in two coastal areas of the Patagonia Argentina inhabited by Commerson´s dolphins, *Cephalorhynchus commersonii*. Acoustic data were collected using a dipping hydrophone from a drifted-boat. Third-octave band received levels were calculated empirically for three categories of vessels, and ambient noise. Two scenarios of sound propagation were considered: cylindrical and spherical, and compared to empirical measurements. Percentages of reduction in range for communication and echolocation were calculated for each vessel in comparison to ambient noise. Sounds were also obtained in presence of Commerson´s dolphins in order to examine possible changes in their acoustic repertoire that could be indicative of a noise impact. Single vessels produce median increases in received levels higher than 10 dB in the broad range of frequencies used by the species. Vessel noise potentially reduced up to 98% the range for communication of Commerson´s dolphins, within 100 meters of the noise source. Non-significant differences were found among commercial, recreational and ecotourism vessels. Variations in the acoustic repertoire of Commerson´s dolphins were registered in noiser environments compared to quieter environments, such as an increase in the proportion of clicks with higher peak frequencies. While these results incorporate several simplifying assumptions, this work contributes to establish a baseline for future assessment of impacts of vessel noise on the species, and proposes recommendations for the management of certain nautical activities, such as dolphin watching to strengthen conservation measures for the species in Patagonia Argentina.

Documenting sub-adults Blainville's beaked whales male-male agression: First underwater video ever recorded (El Hierro, Canary islands).
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Sexual dimorphism appears in Blainville's beaked whales. Adult males have a heavily arched lower jaw with a tusk-like tooth erupted at each side. The forehead and back is full of scars, presumably from male-male aggressions to gain access to females. Here we present the first known video that shows two sub-adults Blainville's males performing what seems to be a male-male aggression. The video was taking off El Hierro (Canary islands). The whole action took part between 1 and 10 meters deep. The individuals engaged in the behavior were i) MdHZ3, a 7 years-old sub-adult male (lower jaw slightly protuberant) known from juvenile and genetically sexed, and ii) MdHX50, a sub-adult male, based on the more arched lower jaw. Due to that, MdHX50 could be older than MdHZ3. During the behavior both individuals initially face at each other at a distance of approximately 20 m. Then they approached frontally at low speed until they were less than three meters apart. After that MdHZ3 rolled over his body and both met head to head and back to back slipping and spinning over each other. Then they separated, swam in circles and repeated the whole sequence. What followed was what seemed to be a chase-beating and retreating behavior: MdHX50 chased and beat MdHZ3 in the flank, while this one insistently retreated. This behavior was performed from MdHX50 over MdHZ3 a number of times, until both animals separated, with no signs of apparent wounds or scars. After that, they stayed in the area together swimming synchronously. Similar behavior has been documented in adult males of Northern bottlenose whales. No female seemed to be present in the near area. The purpose of the behavior described remains unclear; it might suggest training for "real" fighting once adults, playing behavior or maybe even hierarchical purposes.

Population features and threats to the Indo-Pacific bottlenose dolphins (Tursiops aduncus) in Iranian Dolphins' Bay Natural Heritage in the Strait of Hormuz, eastern Persian Gulf
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Background and aims: although small cetaceans in the Persian Gulf suffer from massive anthropogenic impacts, population biology and conservation status of their communities are unknown in most parts of this semi-enclosed shallow sea. A semi-resident community of Indo-Pacific bottlenose dolphins inhabits the Dolphin's Bay Natural Heritage, a nationally protected area (~97 Km^2) and the only Iranian dolphin-watching tourism site, located in the Strait of Hormuz. This study was undertaken to estimate for the first time size, structure, home range, and threats to this dolphin community.

Activities: data were collected during 16 small-boat surveys (~ 27 hours) in December 2017 and February 2018. The photo-identification technique was used to estimate the community size.

Findings and conservation implications: the size of the bottlenose dolphin community was estimated at 126 individuals. In addition, at least four neonates were observed during February, confirming the bay is a breeding habitat for this community. The group size ranged from eight to 100 individuals, observed in one to five subgroups, a mixture of adults, juveniles and calves. Based on previous observations, dolphins usually migrate to unknown areas seaward during late spring and summer months. Our surveys showed that during their presence, their home-range exceeds the easternmost limit of the bay, which calls for an immediate measure to expand the boundaries of the protected area. Fishing activities (e.g. purse-seines, fish hooks, cage-liked traps), which were recorded during 60 % of boat surveys, are the main putative threat for the dolphins. Further, while skippers are not trained for responsible dolphin-watching, tourism boat traffic is another threat for the dolphins. Therefore, the top priority is to cooperate with local communities aiming to promote responsible dolphin-watching, help develop alternative livelihood options for fishers and encourage fishing outside the protected area in order to reduce incidental bycatch and competition for fish resources.

Measurement of progesterone in the blubber of the Franciscana dolphin, Pontoporia blainvillei (Cetartiodactyla; Pontoporiidae), off the coast of São Paulo, Brazil.

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The Franciscana dolphin (*Pontoporia blanvillei*) is a small odontocete endemic to the east coast of South America impacted by anthropic activities, mainly bycatch. The hormonal measurement in biological matrices (feces, urine, milk, etc) has been increasingly used in aquatic mammals for reproductive parameters. The present study validated the method of extraction and measurement of progesterone in blubber in this species besides correlating hormone concentration with gender, sexual maturity, age, stage of development and occurrence of pregnancy. The carcasses were collected from stranded and bycatch dolphins of the coast of São Paulo, Brazil. Stranded during the Santos Basin Beach Monitoring Project (PMP-BS), one of the monitoring programs required by Brazil's federal environmental agency, IBAMA, for the environmental licensing process of the oil production and transport by Petrobras at the Santos Basin pre-salt province. Blubber samples were collected and frozen at -20°C (n=96). After extraction, hormonal analyses were done by enzyme immunoassay and were performed on two units of hormone concentration (ng/g and ng/mg). The inter-assay coefficient of variation was 6.89%, the intra-assay coefficient of variation was 7.82%. The progesterone assay presented parallelism $F1.5=0.87$, $p= 0.45$, the mean extraction efficiency was 66%. No difference was found between measurement units. Progesterone levels were higher in females ($\bar{x}$=14.29±18.87 ng/g) than males ($\bar{x}$=6.25±9.60ng/g) ($Z=-2.15$; $p=0.03$), mature female ($\bar{x}$=32.93±23.39ng/g) than immature ($\bar{x}$=8.03±10.62ng/g) ($Z=2.57$; $p<0.01$), adult females ($\bar{x}$=26.35±25.75ng/g) than juveniles ($\bar{x}$=3.84±4.13ng/g) and calf ($\bar{x}$=14.05±13.65ng/g) ($H(2, N=46)=9.68$; $p<0,001$). Hormone levels of females had no correlation with age ($r=0.35$; $p=0.07$). Pregnant animals ($\bar{x}$=52.35±26.44ng/g) had higher levels of progesterone than the rest of the specimens ($\bar{x}$=8.79±11.79ng/g) ($Z=-3.03$; $p<0.001$), than mature ($\bar{x}$=23.78±21.3ng/g) and immature females ($\bar{x}$=8.65±10.78ng/g) ($df=2$; $F=16.39$; $p<0,001$), generating a biological validation of the use of blubber to estimate pregnancy in this species. These results showed all methods could be validated for *Pontoporia blanvillei.*

Quantifying individual manatee exposure to watercraft disturbance using GPS and long-term acoustic tags.

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Estimates of population consequences of disturbance require information about how often, how long, and where individuals are exposed to the source of disturbance. Exposure data is also key to estimate the cumulative effects of multiple sources of disturbance. Florida manatees (T*richechus manatus latirostris*) are exposed to boat traffic throughout their habitat. Collision with watercraft is the primary anthropogenic cause of manatee mortality and passing boats are known to disturb manatee behavior. However, the cumulative effects of boat disturbance are currently unknown in part because limited information is available on the level of watercraft exposure experienced by individual manatees. Recreational watercraft are not required to carry the Automated Identification System (AIS). Therefore, it is particularly challenging to predict individual manatee exposure levels on biologically relevant scales using traditional co-occurrence methods. To quantify individual exposure to boat traffic, we deployed long-term sound and motion tags (DTAG-4) on three rehabilitated manatees. These individuals were considered naïve with limited exposure to watercraft disturbance before release. DTAGs were integrated into GPS tracking gear and were set to continuously record for up to 48 days at 32kHz sampling rate. GPS positions were collected every 15 minutes. Using the acoustic record from the tag to detect boat passes, we calculated hourly encounter rates and interpolated GPS positions to estimate the location of each encounter. Preliminary results indicate that boat encounters ranged from 0 to 14 passes/hour. Boat passages interrupted feeding and resting and manatees responded to some passes by engaging in travelling behavior, suggesting that there could an energetic cost to boat disturbance. Spatial and temporal exposure data were combined to produce individual-based exposure maps with estimates of disturbance and cumulative effects of watercraft traffic on Florida manatees.

Sperm whale and killer whale depredation on demersal longline fishery: A technological approach to understand animal behavior.
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Toothed whales feeding on fish caught on longlines is a growing issue worldwide. This issue named depredation has a serious economic impact on the fishery economy, and raise questions about fish stock assessment and wildlife conservation. There is thus a critical need for mitigation solutions that requires a good understanding of the depredation behavior. However, depredation by odontocetes on demersal longlines is assessed nearly exclusively from surface observation performed from fishing vessel during hauling phases. Therefore, information on when, where and how odontocetes depredation on demersal longline occurs underwater is still limited.

In the present study, we investigated depredation by killer whales (*Orcinus orca*) and sperm whales (*Physeter macrocephalus*) on demersal longlines in the French Patagonian toothfish fishery (Southern Ocean). Using a combination of animal-borne behavioral and longline-attached data loggers, we revealed that both species are able to depredate longlines on the seafloor. This depredation behavior during the soaking phase raised question about the ability of the whales to detect the longlines. Therefore, using a passive acoustic monitoring we revealed that differences of acoustic signatures of boats between the setting and hauling phases. We hypothesize that this allows odontocetes recognizing the boat activity and therefore localize longline positions.

These results strongly suggest that depredation rates on demersal longlines by odontocetes are likely to be underestimated since interaction events at depth may be unrecorded. For the management of fisheries, these results also suggest an underestimation of the depredation rates which could impact stock assessments. Besides, the evidence that depredation can occur at any time during the whole fishing process should be considered in future developments of mitigation solutions.

Cohort variation in male lifetime mating success and the opportunity for sexual selection in a solitary carnivore, the polar bear
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Despite the important role that population density plays in ecological and evolutionary processes, studies of solitary species that occur at low densities remain scarce. Within the context of mating systems, density is expected to influence the ability of males to find and monopolize mates, in turn influencing variance in lifetime mating success and the opportunity for selection. We investigate variance in male lifetime mating success (LMS) and the opportunity for sexual selection in a sexually dimorphic marine mammal, the polar bear (*Ursus maritimus*) using a multi-generational pedigree. Across 17 cohorts, born from 1975 to 1991, male LMS of 369 individuals ranged from 0-10 mates (mean = 1.43; variance = 3.41) with 40% of known-age males not known to have reproduced. The standardized variance in male LMS (i.e. the opportunity for sexual selection) (I_s = 1.66) was low but varied amongst cohorts (I_s range = 0.60-4.99). Non-breeders represented a significant variance component of LMS explaining between 13%-71% of the total variation in LMS among cohorts. In addition across all cohorts male bears had a positive Bateman gradient (β_{ss} = 0.99, r^2 = 0.93, $p < 0.001$), which indicated lifetime reproductive success was positively influenced by LMS. Our results support a growing body of evidence that suggests that male-biased size dimorphism and polygynous mating systems need not be associated with high variance in male mating and/or reproductive success.

Evaluating the utility of drone technology to survey the remote population of Pribilof Island harbor seals

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Harbor seals are found throughout much of Alaska's coastal marine habitat and have long been significant subsistence and cultural resources of Alaska Native communities.The Pribilof Island stock is a very small, isolated, and under-surveyed population of harbor seals. Historic counts range from 150-300 seals but no effort was made to conduct surveys of all haul-out sites over the same time period. In the summer of 2018, the Aleut Community of St. Paul Island Tribal Government, the Duke University Marine Robotics and Remote Sensing Laboratory, and the NOAA Alaska Fisheries Science Center began a collaborative research project with the main objectives of obtaining a comprehensive survey of the Pribilof Island harbor seal stock and to evaluate the utility of drone survey technology on a remote seal population. Shore- and boat-based surveys were conducted with the use of multiple, small unmanned aircraft systems (sUAS). Two senseFly eBee Plus fixed-wing drones were used to map harbor seal haul-out habitats while collecting high resolution color and thermal IR imagery. A DJI Phantom 4 multirotor drone was also flown over targeted haul-out sites to collect color imagery. Counts from the 2018 surveys summed to 239 harbor seals ashore. Using an approximate correction for seals likely in the water, the current abundance estimate for the Pribilof Islands is 478 seals. This collaborative effort represents the first comprehensive survey of harbor seals conducted in the Pribilof Islands and initial steps towards developing a long-term monitoring and data collection program with the Aleut Community of St. Paul Island.

Partnering with lobster fishermen to reduce entanglement of North Atlantic right whales in the Gulf of Maine with ropeless lift bag fishing systems.

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Sea Mammal Education Learning Technology Society (SMELTS) has created a patent pending Ropeless fishing system that uses compressed air with variable buoyancy lift bags to bring gear to the surface which completely eliminates the vertical line and buoy. The system is complemented by an acoustic modem used to track gear location and trigger lift bag inflation. This is a negatively buoyant fishing retrieval system that has the ability to lift heavy loads from the seafloor to the surface with ease.

WhaleFeast - Ecological, commercial and social implications of the recent extreme winter arrivals of herring and whales in Northern Norway

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In the last nine winters, large aggregations of humpback (*Megaptera novaeangliae*) and killer whales (*Orcinus orca*), have been observed in fjords of Northern Norway as they exploit a newly established overwintering area for the Norwegian spring spawning herring (*Clupea harengus*). This abrupt change in herring distribution was likely caused by the occurrence of the very strong year classes starting to dominate the spawning population, firstly the 2004 age class overwintering in the area from Andfjord to Tromsø during 2010-2016, followed by the 2013 year class overwintering in the Kvænangen fjord further north from 2016 until today. Consequently, there have been major changes in the local ecosystems and a general increase in abundance of other predators in addition to whales, including different fish and bird species. The herring and whales also represent substantial economic opportunities for the local communities, with booming fishery and tourism industries. However, the associated increase in fishery and tourist boat activity have raised concerns about possible impacts on the marine ecosystem and whales in the region, for example related to depletion in dissolved oxygen, whale disturbances and life-threatening entanglements. The WhaleFeast project aims to facilitate planning, knowledge outreach and cooperation between regional research institutions and other stakeholders to generate knowledge exchange and best practices for a responsible co-development of vessel traffic, fisheries and tourism based on the whales and herring. For this we have used a combination of sampling methods, such as whale satellite tracking (including public online real-time tracking), ID-photos, environmental DNA, genetic and contaminant analysis (biopsies), herring abundance assessments, observational studies, interviews and workshops with stakeholders. Combining information from both biology and social science will deliver products to provide advice for optimal co-existence of whales, industry and humans, until the herring again move away from the coast and the feast is over.

Cultural heritage in animals: What is it and why does it matter?

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Policy on biodiversity and species conservation is normally couched in terms of habitat or genetic preservation. I argue that where there exists culture, cultural features and cultural diversity need to be taken into account and valued in policy and management processes. My research focuses on the critically endangered Southern Resident Killer Whale (SRKW) population. These cultural beings are not reducible to their ecological or physiological features, so ensuring their continued existence goes beyond protecting their genetic heritage and habitat. For SRKWs to exist, their cultural heritage must be conserved. First, I argue that their social practices count as culture. Second, I argue that the reasons we have for valuing human cultural heritage apply to the SRKW case, and show how this can inform conservation policy and management.

What is culture? I argue that cultures are real social kinds, which are socially constructed ideas or objects that depend on social practices for their existence. Such phenomena can be grouped together according to their causal or constitutive properties or processes, allowing reliable predictions and explanatory power. The facts of the matter for social kinds are determined (in part) by social factors, rather than (only) physical, biological, or psychological factors. I draw on feminist and critical theory to make my case that culture is grounded in systems of social relationship, and that animal culture need not be precluded.

When it comes to cultural heritage value, conservation is widely considered an inherently values-based activity that can be understood as an expression of meaning and values that are attached to material objects. This can be extended to meaningful landscapes, plants and animals as 'natural heritage', and symbols, meanings, knowledge and know-how as 'intangible heritage'. The value of cultural heritage comes down to the significance that phenomena have for social groups, including the SRKW population.

Actual population size and growth trends of the Galapagos otariids

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Currently, the Galapagos sea lion (GSL) (*Zalophus wollebaeki*) and Galapagos fur seal (GFS) (*Arctocephalus galapagoensis*) are within the most important endemic species for conservation in the Galapagos Archipelago. Both are classified as "Endangered" since their populations have undergone a drastically decline over the last decades. In this study we determined the population size of both otariids and their growth trends based on 5-years counts (2014 a 2018) of animals in all their rookeries, and the influence of environmental variability on pup abundance. The GSL population size in 2018 in the archipelago, after applying correction factors to the counts, is estimated at 17,000 to 24,000 individuals and has increased at an average annual rate (ʎ) of 5.8% over the last four years. The highest number of GSL counted in the archipelago was in 2014 followed by a population decline of 23.8% in 2015, which corresponded to a strong ENSO year. After that, the population increased mainly in northern, center and western rookeries. While GSL pup abundance showed a decreasing trend with the increasing in the intensity of ENSO event. The GFS population size in 2017, based on counts corrected, is estimated at 7,000 to 10,000 individuals and has increased at ʎ = 4.3 % from 2015 to 2017. The highest number of GFS counted was in 2014 followed by a population reduction of 38% in 2015 mainly in the western rookeries. After that, the GFS population experienced interannual fluctuations with different growth trends among regions of the archipelago. The GFS pup abundance has a strong decreasing tendency with the increasing in the sea surface temperature (SST). Our results show both species are highly vulnerable to changes in the SST associated to periodical oceanographic-atmospheric events in the Galapagos ecosystem which impact prey abundance and the flow of energy in the ecosystem.

High-frequency echo sounders produce lower frequency signals audible and with the potential to affect behaviour of marine mammals.
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The use of active high-frequency echo sounders for commercial activities and marine research has been increasing in recent years. While these devices typically operate at centre frequencies outside the hearing range of most marine species, recent work has demonstrated that they may also emit unintended energy at lower frequencies. This may extend into the audible range for several species of marine mammals and have the potential to affect their behaviour. This study measured the full frequency spectrum of a SIMRAD EK60 echo sounder operating at target frequencies of 120 and 200 kHz. Results showed that the generation of both signal types produced broadband energy with frequencies also extending below the system's target frequencies, in the range of 70-100 kHz and 90-150 kHz for the 120 and 200 kHz signals, respectively. For harbour porpoises, the target frequency of the 120 kHz and subcomponents of the 200 kHz signal fall within the region of highest hearing sensitivity and are thus likely detectable. While less sensitive at higher frequencies, measured signal levels indicate that harbour seals will likely also be able to detect the lower frequencies (70-100 kHz) generated by both signal types. Detection of these signals will be dependent on source power, signal duration, repetition rate, signal directionality and the animal's proximity to the beam centre. In addition, detection will be dependent on water depth, local ambient noise and seabed and surface scattering, all affecting signal propagation characteristics. Given the theoretical detectability of these unintended lower frequencies by marine mammals, both signal types have the potential to elicit behavioural responses towards them. This potential conflict should be considered in environmental and behavioural studies using these devices and when planning marine mammal monitoring alongside ecosystem studies using active acoustic sonar systems. p { margin-bottom: 0.25cm; direction: ltr; color: rgb(0, 0, 0); line-height: 115%;

Strengthening the ecological toolbox: Analysis of alkenones in four cetacean species to estimate environmental water temperature.
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Alkenones are a group of molecules synthesised by cosmopolitan haptophyte organisms. These

molecules are extremely resistant to degradation and the unsaturation index ($U^{k'}_{37}$) of di- versus tri-unsaturated C37 alkenones ($C_{37:2} \cdot (C_{37:2}+C_{37:3})^{-1}$) can be used to estimate the temperature of the water in which the alkenone-producing organisms grew. Thus, alkenones can be found in thousands-of-years-old sediments and palaeoceanographers have used them to measure the water temperature in the past. However, this useful technique has received little attention in other fields. In this study, we developed a method to detect the alkenones in cetacean tissues and analysed them on one mysticete from the North Atlantic (*Balaenoptera physalus*) and three odontocetes from the Mediterranean (*Tursiops truncatus*, *Stenella coeruleoalba* and *Grampus griseus*). The results show the presence of alkenones in most samples of the blubber of *B. physalus* and the krill present in their stomach, as well as in the blubber of *S. coeruleoalba* and *G. griseus,* but they were present in only a few blubber samples of *T. truncatus*. The low prevalence of alkenones in *T. truncatus* may be caused by the coastal distribution of this species, in contrast with the oceanic distribution of the other three. The environmental temperature derived from the $U^{k'}_{37}$ in the samples from *B. physalus* and *S. coeruleoalba* was consistent with the average of their habitat while some of the *G. griseus* samples indicated values that were too low for the Mediterranean Sea (below 10 ºC). Our results confirm that alkenones are transmitted through the trophic web and can be detected in cetacean tissues. However, further research is required as some factors, e.g. the coastal habitat of *T. truncatus* or the mesopelagic prey preferences of *G. griseus*, appear to affect the abundance and $U^{k'}_{37}$ index of the alkenones in their tissues.

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Revisiting differential reproductive rates in Gulf of Maine humpback whales in relation to mitochondrial lineages

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Variance in reproductive success among con-specificindividuals can potentially result in changes in haplotype (i.e. alleles) frequencies. A prior study found differential reproductive rates in two clades of humpback whales (*Megaptera novaeangliae*) sampled in the Gulf of Maine, and predicted an 11% decline in one clade versus a 30% increase in the other over a 75-year period. Here, we re-examined evidence for this finding after increasing the sample size by an order of magnitude and extending the period of observation by 21 years. The mt control region (mtCR) was sequenced for 1507 individual humpback whales sampled in the Gulf of Maine, including 318 mature females. Twenty-three haplotypes were identified among the mature females and used to build a Bayesian genealogy which confirmed two well-differentiated clades (BCD and IJK). Calving rates were estimated annually by clade for the same period as the prior study (1979-1995) and also extended through 2016. Whereas significant differences were found in reproductive rates over time in the prior study, larger sample sizes revealed comparable trends for both clades, both within the prior period and in subsequent decades. No statistically significant differences in reproductive rates were found at different levels of the maternal co-ancestry. Our study indicates that mt haplotypes and mt clades are not correlated with a differential reproductive rate in female humpback whales in the Gulf of Maine, and suggests against significant short-term mtCR-based selection.

Molecular identification of trematode parasites of West Indian manatees (Trichechus manatus), and their role as bio-indicators of their distribution and diet

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Sirenians are hosts to a variety of parasites, which cause little or no pathology. In the Greater Caribbean, West Indian manatees (*Trichechus manatus*) harbor several major metazoan endoparasites, including a stomach nematode (*Heterocheilus tunicatus*), a nasal trematode (*Pulmonicola cochleotrema*) and five intestinal trematodes (*Nudacotyle undicola*, *Monoligerum blairi*, *Anaplocephala*sp., *Chiorchis fabaceus,* and *Chiorchis groschafti*). Parasitological studies have recommended the use of the latter two as bio-indicators of population distribution. Manatees live in varied habitats (marine, estuarine, fluvial, lake), but the relationship of these to their life history, and thus how it relates to their internal parasites, has not been studied. We sought to identify *Chiorchis* spp. through molecular analysis in different areas of the Caribbean. Ribosomal RNA gene of trematodes collected from 43 carcasses of manatees from Puerto Rico, Florida, Dominican Republic, and Colombia were amplified using the degenerate primers. For comparison purposes, intestinal trematodes were also collected from a dugong from Malaysia. Seventy-seven samples were sequenced and phylogenetic reconstruction was made with 313 bp of the 18S rRNA sequences using representative samples of each geographic location. The trees produced the same values of 100% of the posterior probability for Bayesian Inference and bootstrap values for Maximum Likelihood analysis for *Chiorchis* spp. and *S. travassosi*. We found that *C. groschafti* and *S. travassosi* infect only manatees and dugongs, respectively, in marine habitats in which they feed primarily on sea grasses. In contrast, *C. fabaceus* infects manatees living in fresh-water habitats in which they feed primarily on fresh water aquatic vegetation. Some manatees in Florida were infected with both species, indicative of their movement between marine and fresh-water habitat and their combined diet of sea grasses and other aquatic vegetation. This study documents how *Chiorchis* spp. serve as ecological bio-indicators of manatee habitat distribution and markers of their herbivorous diet.

Comparative morphology of the prostate of odontocete cetaceans: A histological, histochemical, immunohistochemical and ultraestructural study.

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The prostate is the only male accessory gland described in cetacean. Only the anatomy and histology of the prostate of few species of these mammals has been described in the literature, and for most species this organ has not been studied. Pathologies of the cetacean's prostate has been reported and potentially can impair the reproduction, hence the importance of investigating the normal anatomy of this organ in such species. The aim of this work was to describe the morphological characteristics of the prostate of different odontocete cetaceans by histological, histochemical, immunohistochemical and ultraestructural techniques. The prostatic gland of 47 animals of nine different species was grossly and microscopically studied. Members of the family Delphinidae, Zhiphiidae y Physeteridae were included. In general, the prostate was a musculo-glandular organ with two distinct parts: The *Corpus prostatae* and the *Pars disseminata*. In the pygmy sperm whale (*Kogia breviceps*) and the Cuvier's beaked whale (*Ziphius cavirostris*), the prostate was a discrete gland with a small *Corpus prostatae*. Histologically the prostate consisted in acini and ducts, lined by a simple cuboidal epithelium, and organized in lobules. The prostates of mature and immature animals were compared. Immunohistochemical analysis was performed using low and high molecular weight cytokeratin, vimentin and prostatic specific antigen (PSA) commercial antibodies. Electron microscopy of the prostate of a bottlenose dolphin was performed and cytomorphological differences among major epithelial components of the prostatic epithelium were described. This work represents a comparative analysis of the morphology of the prostate of various cetaceans' species.

Drivers of distribution for the endangered Burrunan dolphin (Tursiops australis), anthropogenic or environmental influences?

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The Gippsland Lakes, Victoria, Australia, supports a small resident maternal-based population of Burrunan dolphins (*Tursiops australis*). The Burrunan dolphin, recognised as vulnerable fauna within the Gippsland Lakes Ramsar site, is currently listed as Endangered under Victoria's Flora and Fauna Guarantee Act. There is now a high priority to protect this geographically and genetically isolated population. Seasonally, we see a dramatic and repeated shift in Burrunan dolphin distribution across the 75km long estuarine lake system. Potential drivers for this shift in distribution include habitat use, benthic structure (supporting lower trophic levels), prey availability and anthropogenic activities such as vessel use. The observed distribution shift coincides with a seasonal increase in vessels, with a high degree of non-compliance to approach Regulations observed. But is this the cause of the seasonal shift? To explore this further, seasonal boat-based surveys (2017-18) recording Burrunan dolphin sightings and behavioural observations were undertaken, and geospatially mapped to identify areas of significance for core-biological activity (i.e. feeding, resting/milling). In addition, habitat assessment and biotope mapping of key areas were undertaken via the Combined Biotope Classification Scheme (CBiCS). Methodologies included Autonomous Underwater Vehicle (transect and mosaicked images) and drop cameras (point location) collecting georeferenced seabed imaging for benthic flora and fauna composition and seabed features; and single-beam acoustic transects for seabed assessments. These assessments resulted in the classification of approximately 11 habitat biotopes, four of which were newly described for the Gippsland Lakes. Finally, to assess whether the benthic structure and habitat are key drivers in seasonal distribution of the dolphins, we used geospatial mapping to overlay the sightings and behaviour with the habitat biotopes.

Fin whale behaviours change during close-encounters with large ferries: Investigating ship strikes from platforms of opportunity.

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An unknown number of vessels collide with whales ('ship strike'), causing mortality and injury. In addition to these direct impacts, indirect impacts are likely as ships may alter whale behaviour when a close encounter or near miss occurs. Fin whales (*Balaenoptera physalus*) are the most frequently hit whale species globally. The Bay of Biscay presents an ideal area to study ship strike risks due to high densities of fin whales in summer months, coupled with extensive shipping traffic. A partnership between a university, a marine conservation charity, and an industrial partner operating large ferries across the Bay of Biscay has enabled novel research into interactions between large whales and ships. Data on fin whale behaviour, breathing rates, and surface intervals were collected, alongside distance and bearing to the ship, from the bridge of a large ferry (185m length). The non-lethal effects of close-encounters between large vessels and fin whales were investigated and near-miss encounters quantified. During 4,828km of survey effort in the pilot study, 34% of fin whales sighted came within 500m of vessels, and on eight occasions the ship altered course to avoid collisions with animals. The breathing rates of animals increased significantly as the vessel approached, and dives were longer after close encounters with a vessel. This pilot study showed that large ferries provide an appropriate platform of opportunity for research into ship strikes and near-misses and can provide context of whale behaviours and drivers that may affect the likelihood of ship strikes. The continuation of this monitoring work is discussed, including the use of videogrammetry to measure accurate distances, bearings and to collect behavioural data at a finer scale. These findings will be used in models to highlight areas of risks and possible mitigation strategies.

Abundance, population growth and latent mortality of humpback whales in the Gulf of Maine in relation to human activities

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Humpback whales (*Megaptera novaeangliae*) are exposed to a high level of human activity in the Gulf of Maine relative to other primary North Atlantic feeding grounds. Serious injury and mortality from observed entanglements and ship strikes have consistently exceeded management limits, but the population-level effects of these and unwitnessed events have yet not been evaluated. We used a mark-recapture data set from 2000 through 2016 to estimate abundance, survival, population growth rate and the impacts of human activities. Data were obtained through dedicated photo-identification surveys across the Gulf of Maine and high-intensity data collection at smaller scales throughout the region. Population parameters were estimated annually using a hierarchical, Bayesian state-space model that included sex, age, and a random time effect on survival while allowing sex, annual and individual whale effects on capture probability. Based on the posterior distributions of parameter estimates, median abundances ranged from a low of 893 individuals in 2001 to a high of 1,393 in 2016. Average annual population growth was estimated to be 2.8%. The annual number of reported entanglements was not correlated with population size, and there was no evidence that the *per capita* entanglement report frequency declined after Federally-mandated changes to fishing practices in U.S. waters in 2009 and 2015. Model results also did not suggest overall improvements in population survival rates after 2009. An estimated increase in survival from 2015 to 2016 may have been related to a required reduction in fixed gear buoy lines, but requires further investigation. Observed serious injuries and mortalities from all human sources in US waters accounted for at least one-quarter of the estimated number of deaths. This long-term study of individual humpback whales suggests a slowly growing population with on-going impacts from anthropogenic activities.

First record of a grey seal predating a shark in the UK: Combined evidence of a global trend for novel seal diet, or something we've missed all along?

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Predator-prey interactions have significant effects on food web stability, population dynamics and ecosystem linkage, and for threatened species in conflict with human food industry, a clear understanding of their trophic ecology is critical. Here we report the first record of a managed predator that is in conflict with commercial fisheries in the UK, the grey seal (*Halichoerus grypus*), killing and consuming a managed shark species, tope (*Galeorhinus galeus*). We present scenarios that may explain why this is the first recorded case, and discuss important ramifications. Competition with commercial fisheries and harbour seals (*Phoca vitulina*), plus climate-driven prey scarcity could be driving individual specialisation for feeding on tope and/or be responsible for a wider trophic shift in the diet of grey seals in the UK. Both paradigms could have serious implications for management of protected species and other threatened shark species that may be involved. The scenarios and evidence presented here could have important implications for our understanding of grey seal diet not only in the UK, but also across their range. Evidence indicates that seal species globally may be altering their diet, which could have significant effects on managed species, fisheries and food webs worldwide. Methodologies to improve our understanding of seal diet are also suggested.

Assessment of spatial distribution of industrial gillnet fishery fleet and its overlap with franciscanas (Pontoporia blainvillei) in southern Brazil.

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The franciscana, *Pontoporia blainvillei*, is endemic and one of the most threatened small cetacean in the Southwest Atlantic Ocean. Due to its coastal habits (up to 50m) gillnet fisheries bycatch is the main conservation threat faced by the species. In southern Brazil (SBr)(Franciscana Management Area III–FMAIII), bycatch is considered unsustainable for franciscanas. Here, we used data from official logbooks to assess the spatial distribution of the industrial gillnet fishery fleet off SBr in 2017. Additionally, franciscana's sightings recorded during aerial surveys conducted off SBr in the summer of 2014, up to 50m deep, were used to evaluate the existence of an overlap between franciscana occurrence and net sets locations. Density (sets/km²) and encounter rate (ER) of franciscana's group/km were calculated between 0-10m,11-20m, 21-30m and 31-50m isobaths for the whole period and for the summer. The FMAIII was divided in FMAIII-N (27°S to 30°S) and FMAIII-S (30°S to 33°S). A total of 4,081 sets was analyzed (FMAIII-N: n=133, 0.014/km²; FMAIII-S: n=3,948, 0.144/km²). Density and ER varied as followed: FMAIII-N i) 0-10m: annual=0.001/km², summer=0/km², ER=0/km; ii)11-20m: annual=0.007/km², summer=0/km², ER= 0.181/km; iii)21-30m: annual=0.017/km², summer=0.001/km², ER=0.041/km; iv) 31-50m: annual= 0.013/km²; summer=0.0003/km², ER=0.056/km and FMAIII-S i)0-10m: annual=0.067/km², summer=0.013/km², ER=0/km; ii)11-20m: annual=0.194/km², summer=0.039/km², ER=0.053/km; iii)21-30m: annual=0.195/km², summer=0.052/km², ER=0.030/km, iv)31-50m: annual=0.059/km²; summer=0.025/km², ER=0.013/km. Our findings shown that sets/km² and ER are mostly concentrated at the same interval of depth (11-30m), revealing a large overlap between the franciscanas and fishing nets. These results could explain the high level of franciscanas´s bycatch in FMAIII. Due to the lowest sets/km² and higher ER in FMAIII-N, we suggest the withdrawal of the industrial gillnet fleet beyond 50m (~27km from the coast) in this area. Seasonal variation on the franciscana´s occurrence and the spatial distribution of the artisanal fleet should be also considered to build an effective conservation plan for the species.

Moving towards a sustainable cetacean-based tourism industry – case study in Mozambique.

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Cetacean Based Tourism (CBT) is often confused with sustainable tourism. However, not every CBT operator has an environmental education component. In reality, tourism activities have proven to have many negative impacts to the animals and management is required to mitigate potentially-harmful effects. This study analysed the attitudes and perceptions of the marine operators and tourists that partake in dolphin-swim activities in the Ponta do Ouro Partial Marine Reserve (PPMR) in Mozambique. In this reserve, a resident population of Tursiops aduncushas been exposed to constant CBT since 1994. Boat traffic in the area (tourism and recreational) has suffered an increase of over 50% during the quiet months. The number of operators offering dolphin-swims has also increased from one to four. Observations were madeduring dolphin-swim activities onboard a CBT boat to quantify changes in dolphin distribution and behaviour. Attitudes and perceptions were studied using a hand-out questionnaire survey with close-ended and Likert scale type questions. Finally, assessment of the biological interpretation provided by operators were assessed via observation of pre-, during, and post-activity communications. Results show that the tours are an effective method to promote a pro-environmental behaviour and consequently increase compliance to the dolphin, whale and whale shark Code of Conduct (CoC). Nonetheless, both tourists and operators displayed only basic knowledge of the regulations of the reserve and of the CoC, indicating a need for improvement. There were short-term negative impacts on the dolphin population: the quality of human-dolphin interactions decreased as well as number of sightings in areas of high vessel traffics. A series of

recommendations were developed to create an effective interpretation programme for all operators, support the revision of the management plan, and to assist in devising guidelines for CBT at both national and international levels.

Ship strike management in priority regions of the U.S. West Coast: Effectiveness of past efforts and potential for new strategies.

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Ship strikes are a major source of death for endangered blue, humpback and fin whales on the U.S. West Coast. Quantifying and mitigating ship strikes is an important step to ensure the recovery and resilience of whale populations. We used an encounter rate model based on ship data from AIS and whale habitat models to examine ship strikes in two high-risk areas: waters off Los Angeles/Long Beach and San Francisco Bay. We estimated ship strike deaths and their spatial patterns over five years for each location. In addition, we modeled and compared the effect of past voluntary and incentivized programs on whale mortality. Next, we simulated scenarios in which greater proportions of vessels complied with speed limits to examine the potential impact of increased participation in current speed programs or instatement of mandatory regulations. Finally, we identified additional areas outside the current extent of speed management that show the greatest additional mitigation potential and evaluated the hypothetical reduction in mortality from adding speed limits in those areas. Cooperation with voluntary speed limits increased moderately with management efforts and maximum reduction of modeled mortality in the managed areas was about 13% compared to before speed limit were implemented. Some of that reduction was from management efforts, but some stemmed from a long-term decline in ship speeds as companies employ 'slow steaming' to decrease costs and lower emissions. Off San Francisco, high compliance (80-90%) similar to that achieved with mandatory regulations on the U.S. East Coast could result in approximately twice the decline in deaths as has been achieved. The implementation of additional speed management areas would further decrease strike deaths. To effectively address one of the top human threats to whales, managers need to consider pursuing greater cooperation with speed limits and expanding those limits to key areas of risk.

Genetic study using mitochondrial ADN of sperm whales (Physether macrocephalus) of the Macaronesia.

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The sperm whale is a cetacean with a cosmopolitan distribution and a complex matriarchal social structure. It is common in the Canary Islands throughout the year, suggesting that the archipelago holds a resident population. However, there is scarce knowledge about the biology and population structure of the sperm whale in the archipelago and overall Macaronesian region. This species is considered vulnerable and suffers a high ship-strike mortality in the Canary Islands, affecting mainly females and young, and it has been proposed that the archipelago could be an attractive sink habitat for Macaronesian sperm whales. Here we investigate this possibility by assessing genetic connectivity among the Canary, Madeira and Azores archipelagos. The results confirm the known low variability of mitochondrial DNA in sperm whales and shows an apparent lack of female connectivity between i) Azores, and ii) the Canary Islands and Madeira archipelagos, while there is some genetic flux of both sexes between the Canary Islands and Madeira. These results are consistent with previous findings in other places of site-fidelity in females and long ranging males. Observed photoID recaptures of female sperm whales among archipelagos can be reconciled with our results if there are subpopulations with different degree of site fidelity in Macaronesia. Results are applicable for conservation management of the species, as they suggest that the genetic replacement of female sperm whales dead by ship strike will be geographically limited. This increases the potential for a population level impact of ship strikes on sperm whales in the Canary Islands. The results also underline the need to increase sample size in the archipelago and surrounding region to base conservation measures for the species in the Macaronesia.

Use of SNPs to investigate the molecular epidemiology of M. pinnipedii infections.

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Tuberculosis (TB) due to *M. pinnipedii* has been diagnosed in 31 New Zealand (NZ) marine mammals, including an endangered Hector's dolphin. It has also been identified in tuberculous lymph nodes in NZ cattle. Genotyping by VNTR-DR showed that isolates from NZ sea lions, fur seals and cattle were distinct from each other and from Australian isolates. The Hector's dolphin isolate was the same type as found previously in 3 NZ cattle. Similarities between genotypes identified by VNTR-DR can sometimes to be due to homoplasy, however, where the same copy number at certain loci develops independently in epidemiologically distinct isolates. Therefore, to further investigate the epidemiology of *M. pinnipedii*, we used whole genome sequencing (WGS) and single nucleotide polymorphism (SNP) analysis. To date, 11 NZ and Australian *M. pinnipedii* isolates have been characterised by WGS and their relationship to other TB complex and *M. pinnipedii* isolates established via comparisons of SNP content. These isolates cluster separately from other TB complex organisms and appear more closely related to *M. microti* than other members of the TB complex. NZ isolates also cluster separately from ancient Peruvian human strains. SNP profiles suggest at least 3 major sub-clusters and a possible common source for the cattle and dolphin infections. We developed SNP assays based on WGS clustering and conducted these on 37 *M. pinnipedii* isolates, confirming the clustering patterns predicted by SNP phylogenetic analysis. In addition, these SNP assays were successfully conducted on 6 of 8 formalin-fixed paraffin-embedded (FFPE) tissues from animals with *M. pinnipedii*. SNP assays show promise for use in investigating the epidemiology of *M. pinnipedii*, including using archived FFPE samples.

The depths of winter: Seasonal distribution and abundance of deep diving cetaceans in the North-East Atlantic.

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For wide ranging marine vertebrates with high locomotory capabilities, understanding relative abundance, distribution, habitat use and seasonal occurrence is of importance for conservation and management. Amongst the cetaceans, the susceptibility of deep diving species to anthropogenic noise, including seismic activity and military sonar has increased awareness around the timing and the extent of these activities. Ireland's offshore waters cover a large geographic area with complex bathymetry and oceanography, supporting a high cetacean diversity. Dedicated aerial line transect surveys conducted in summer and winter over two years, comprising 18,000 km of survey effort, in an area of 328,596km^2 resulted in 181 sightings of at least five deep diving species, comprising 568 individuals. Long-finned pilot whales were the most frequently recorded, comprising 52% of the sightings. Beaked whales (Ziphiidae) comprised 40% of the sightings, with some differences in sightings rate/species. Pilot whales were seen in all seasons, with the seasonal point estimates for the whole area varying between 3,080 and 9,036 individuals (with associated CVs between 0.31 and 0.41), showing no strong summer/winter pattern. At least three species of beaked whales were confirmed, with Cuvier's beaked whale most frequently sighted, in waters greater than 1000m depth and in winter, while Sowerby's beaked whales were seen in waters between 500 and 1000m. Seasonal densities of all beaked whales varied across the survey area between 0.005 and 0.015 individuals/km^2, and highlights the waters overlying the continental shelf margin west of Ireland as being particularly important for these deep diving cetaceans. The lack of strong seasonal differences in the abundance and distribution of all these species suggests that these offshore Atlantic habitats are suitable, at least during summer and winter, for most of the identified species, providing a baseline for future management and conservation efforts.

Singing in the deep: A description of sounds and repeated whistle types recorded from melon-headed whales (Peponocephala electra) in the Bohol Sea, Philippines.

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Melon-headed whales (Peponocephala electra) are widespread throughout tropical and warm-temperate waters, but data on their acoustic behaviour remains scarce. While generally pelagic, melon-headed whales are known to frequent inshore areas near islands in the Pacific Ocean, such as the Northern Bohol Sea, Philippines. Between 2010 and 2012, we conducted 59 boat surveys from two locations in Bohol. Melon-headed whales represented 34% of the total sightings, corresponding to almost one sighting per survey-day. We record acoustics on five occasions in 2011 and 2012 during single species encounters of melon-headed whales, which allowed us to characterize their vocalizations. To describe whistle characteristics, we analysed a total of 84 minutes of acoustic recording using Avisoft (Avisoft Bioacoustics). We compared acoustic recordings from the Caribbean and Hawaii to provide insight into inter-population variability. Out of 611 whistles identified, 594 were categorized. Whistles fell into six whistle contour categories, predominantly upsweeps (33.2%), sinusoidal (17%) and constant frequency (16.5%). Frequencies ranged from 3.7 kHz to 25.1 kHz, and varied in duration, (mean= 0.572s, range=0.04-2.84s). Although parameters were similar to other geographical regions, whistles from the Philippines had an emphasis on higher start and minimum frequencies, and vocalisations fell into a wider frequency range. We visually grouped all whistles into categories of repeated whistle types, with 73 identified subcategories. We used the Signature Identification method (SIGID) to identify whether these vocalizations were signatures whistles, and 21 repeated whistles types fit the expected structure. While the underlying reason behind regional variation in melon-headed whale whistles warrants further investigation, this study represents the first dedicated work on the acoustics of melon-headed whales in South East Asia and sets the baseline for further reasearch.

Foraging strategies in wild harbour porpoises: Physiological vs. ecological drivers of diving behaviour.

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Optimal foraging theory predicts that breath-hold divers should maximize the proportion of time spent foraging by consistently diving close to their aerobic dive limit (ADL). This framework has mainly been developed for deep-diving endotherms with relatively long transit times between food at depth and oxygen at the surface that may prioritize physiological over ecological drivers of dive time. This suggests the hypothesis that ecological drivers of dive times are more important for shallow divers, with short transit times to prey. We tested that hypothesis by studying harbour porpoises that forage almost continuously in shallow Danish waters to fuel their high metabolic rates. We quantified the cost of different behaviours using high-resolution sound and movement recording tags (DTAGs) that record depth, breathing, foraging and relative activity. Tagged porpoises (n=19) performed shallow (95-percentile=23m), short (95-percentile=125s) dives that were grouped using Hidden-Markov models into three behavioural states: non-foraging, pelagic-feeding and bottom-feeding dives. Almost all dives were less than half of each individual's estimated ADL. The drivers of dive duration appeared to change with foraging mode: bottom-feeding dives showed a negative relationship between transit and foraging time suggesting termination due to oxygen depletion, while dive duration increased with transit time in pelagic-feeding dives, suggesting an effect of patch quality on dive termination. Pelagic-feeding dives were more energetically expensive than benthic dives judging from post-dive respiration rates and proxies for activity. We suggest that porpoises adjust their foraging behaviour to prey distribution and quality, using more energetically expensive pelagic feeding in high-payoff prey patches and a more economical, but potentially less rewarding, bottom-feeding mode when prey are scarce. This prey-dependent foraging strategy allows porpoises to capitalize on

proximate prey while diving below their ADL, which may enable them to reduce their dive response while digesting and foraging concurrently to support their high metabolic rates.

Learning the hard way: the vaquita case.
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What can the case of the vaquita tell us about ex-situ conservation?

This is a potentially valuable but complex tool for marine mammal recovery. Building capacities takes years and needs to be started long before ex-situ conservation is urgently needed. It's important to start considering the careful planning of phased conservation interventions as human-caused mortality drives populations from abundant to vulnerable to critically endangered.

Fecal thyroid hormone as a biomarker of nutritional status in North Atlantic right whales (Eubalaena glacialis).
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The western North Atlantic right whale (*Eubalaena glacialis*; NARW) population has recently experienced declining calving rates and deteriorating health. Nutritional insufficiency, due to shifts in the zooplankton prey resource, has been hypothesized as a factor contributing to these trends. In this study, we investigated fecal thyroid hormone (fT3) as a biomarker of nutritional status in NARWs. Thyroid hormones regulate metabolism, and are especially responsive to thermal and nutritional stressors, decreasing during chronic food shortages to conserve energy. The study objectives were to: 1) validate a fT3 immunoassay; 2) investigate fT3 by sex, life history stage, and season; 3) compare fT3 in whales killed by vessel strike or fishing gear entanglement to healthy whales; 4) explore fT3 trends over two decades and, 5) examine the relationship of fT3 to stress-related adrenal hormones, corticosterone (fGC) and aldosterone (fALD). From 1999-2018, 397 fecal samples were collected and assayed for fT3, fALD, and fGC. A subset of samples (n = 110) were linked to identified whales with associated life history data. General linear models were used to examine fT3 concentrations by sex, reproductive state, and season, and to compare fT3 in whales killed by human activities vs. healthy whales. Results showed fT3 was highest in calves nursing on energy-dense milk and lowest in females recovering from lactation. There was significant seasonal variation, with lower fT3 in spring, and increasing levels throughout summer and autumn as whales gained energetic reserves. Fecal T3 was significantly lower post-2012 coinciding with declining health and decreased calving rates. Fecal T3 was positively correlated with fALD and fGC, and did not differ in human-related mortalities.This study shows that fT3 levels reflect nutritional state in right whales, and recently lower fT3 levels support the hypothesis that insufficient prey resources are contributing to deteriorating population health and depressed reproduction.

Novel non-invasive techniques for health monitoring and investigating the physiological response to stressors in cetaceans
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There is a critical need for the ability to assess health and monitor the physiological impact to stressors (e.g. sound, shipping traffic, etc.) in cetaceans, particularly for conservation and management purposes. Blood has always been the "gold standard". However, blood sampling requires capture and restraint, and can be time consuming. Mystic Aquarium is developing and validating novel non-invasive techniques for assessing health and the physiological response to stressors in cetaceans. While these techniques are being ground-truthed under controlled conditions on Aquarium belugas, they will be transitioned to free-ranging whales and/or used during controlled experimental paradigms (e.g. sound exposure studies to investigate the physiological impact of sound). Two females and one male beluga were trained behaviorally for blood, blow, saliva and fecal collection. Sample collection occurred on a routine basis at the same time of day to collect enough material for assay validations (i.e. parallelism, accuracy, recovery, assay variability) and to measure cortisol and/or fecal glucocorticoid metabolites. For biological validation, whales were

sampled for all tissue matrices before, during and after an out-of-water event (OWE) for veterinary examinations. All three whales exhibited increased average plasma (pre=1.6 µg/dl, 30 min=8.4 µg/dl, post=1.9 µg/dl), blow (pre=0.13 µg/dl, 30 min=0.38 µg/dl, post=0.15 µg/dl), and salivary (pre=0.01 µg/dl, 30 min= 0.051 µg/dl, post=0.011 µg/dl) cortisol from baseline to 30 min OWE with the exception of the male who showed a lag time in peak cortisol. Fecal glucocorticoid metabolites increased 2- and 4-fold from baseline to 6.5 hrs post exam in the male and one female. This study is the first to show the time course of cortisol and its metabolites simultaneously in blood, blow, saliva and feces. All tissue matrices show promise for monitoring health and the physiological impact to stressors in wild and managed care cetaceans and will be useful in controlled experimental studies.

Are acoustic devices with low sampling rates effective in ecological studies of coastal bottlenose dolphins?

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Echolocation is used by odontocetes for navigation and foraging. Passive acoustic monitoring efforts use detection of echolocation clicks to study distribution, habitat use, and behavior of many species. In general, however, acoustic devices with a sampling rate of up to 500 kHz are expensive. Thus, the use of recorders with a lower sampling rate and lower-cost, such as 48 and 96 kHz, may be an alternative for monitoring programs. Although the clicks produced by bottlenose dolphins are broadband, in general ranging from 0.01 to 150 kHz, the proportion of clicks emitted at lower frequencies are still unknown. Here, we investigated the proportion of clicks that can be detected below 24 and 48 kHz, in recordings up to 96 kHz. We used a Sony PCM-D100 digital audio recorder with a sampling rate of 192 kHz, connected to a Reason TC 4032 hydrophone (frequency range: 0.005 to 120 kHz) to record coastal bottlenose dolphins (*Tursiops truncatus gephyreus*) from a resident population in southern Brazil. We conducted the recordings in a lagoon system (mean depth of two meters, muddy bottom). We analyzed 1h15min of recordings of six different groups of dolphins. We used Raven Pro 1.5 to create spectrograms and analyze the clicks. We counted a total of 27,108 clicks recorded up to 96 kHz. Approximately 99.6% of the total clicks were detected below 48 kHz and 94.6% at frequency below 24 kHz. The proportion of clicks detected below 48 kHz is significantly higher than the proportion of clicks detected below 24 kHz (χ^2=1198.7, df=1, p<0.001). However, less than 6% of the total clicks are undetected below 24 kHz. We conclude that, at least for coastal bottlenose dolphins, ecological studies can use lower-cost acoustic devices with sampling rates of 48 or 96 kHz with no substantial loss in detection rates of clicks.

CeNoBS – a step closer in completing a generation dream: Basin-wide survey of cetaceans in ACCOBAMS area.

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The European Marine Strategy Framework Directive (MSFD) aims at implementing a precautionary and holistic ecosystem-based approach for managing European marine waters, towards achieving their Good Environmental Status (GES). Eleven high level qualitative descriptors (D1-11) aim to describe what the environment will look like after GES has been achieved. The CeNoBS project was designed to "Support MSFD implementation in the Black Sea through establishing a regional monitoring system of cetaceans (D1 - Biodiversity) and noise monitoring (D11-Energy) for achieving GES". The Black Sea is a semi-enclosed sea with a narrow connection to the Mediterranean, containing the largest anoxic

water mass on the planet. Three Black Sea cetacean subspecies (*Tursiops truncatus, Delphinus delphis, Phocoena phocoena*) are already under much anthropogenic stress such as bycatch, pollution, underwater noise, prey depletion due to overfishing and human-mediated biological invasions. It has been impossible, however, to evaluate the level of such impacts as there have been only scarce baseline data available on the population abundance and distribution of these cetaceans in recent times. By implementing a dedicated aerial survey using the line transect distance sampling method in summer 2019, CeNoBS will strongly contribute to provide these baseline data, which has been anticipated in the Black Sea for over a generation. Moreover, CeNoBS will aim to elucidate the bycatch pressure and enhance the methodology of bycatch assessment, as well as to reinforce national expertise to implement effective noise monitoring. A great number of partners from the Black Sea riparian countries (Ukraine, Bulgaria, Romania, Turkey, Georgia) collaborate to implement the largest cetacean survey ever conducted in their region, which will complement the macro regional approach undertaken by the ACCOBAMS Survey Initiative (ASI) for improving the conservation of cetaceans and their habitats in the agreement area. **Keywords:** Black Sea; CeNoBS; MSFD; GES; Harbour porpoise; Bottlenose dolphin; Common dolphin; European Union

Mobilizing Hawaiian monk seal data accessibility for the 21st century.

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Hawaiian monk seal (*Neomonachus shauinslandi*) research has generated one of the world's most comprehensive marine mammal population data sets. In its current form, much of the data are not accessible in real time, particularly in remote field settings where the majority of monk seals reside. The goals of this study are to identify and evaluate new technologies to streamline data collection, and put valuable data at the fingertips of biologists in the field where access to critical life history information like molt status or previous handling sensitivity can radically alter the immediate course of action for both research and response activities for a given individual. Electronic tablets were deployed during the 2018 field season to determine the feasibility of live data entry into a master database. Seal population assessment data were collected using two methods: on paper forms with data entry following the survey and on tablets where data were entered directly into the master database. Little difference was observed in time expenditure between the methods, and field personnel found tablet use in the field challenging. To address limitations identified in this pilot season, focus has shifted to using smaller mobile devices as reference resources rather than data entry tools. During the 2019 field season, we will evaluate paper reference resources updated manually against mobile reference databases updated electronically through the master database. We hypothesize this will save time by minimizing manual updates to paper forms, and increase both accuracy and consistency within the data by minimizing user error. The development of an accessible mobile database will contribute to monk seal population assessment and conservation activities by increasing efficiency, aiding decision-making, and enhancing animal safety. Mobile data management systems have the potential to aid research for numerous marine mammal species which typically inhabit remote regions far from the office computer.

Life at the edge: The limits on underwater behavior of air breathing Southern Ocean predators.

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Marine mammals and seabirds undertake a form of central-place foraging because they must obtain their food at depth yet are obliged to return to the surface to breathe. Prey are not evenly distributed in space and time requiring predators to balance their metabolic needs. Over the last four decades, advances in data-logger technology have greatly increased our ability to study the diving of free-ranging marine animals, to quantify extreme behaviours – such as the deepest and longest dives – and how marine predators regulate their dive cycle. In our study, we aim to identify the underlying processes that characterize marine predators' diving capacity using historical and contemporary time-depth recorder data of three species of seals and three species of penguins

inhabiting the East Antarctic sector of the Southern Ocean. By performing a comparative analysis of relationships between basic dive parameters (e.g. dive duration, dive depth, post-dive interval) and between dive parameters and body mass across species we investigate marine predators diving limits. Through application of the first hunting time method, we examine how different species adjust their diving behaviour whilst foraging, and particularly how the diving response adjusts during high foraging effort (e.g. in response to changed prey distribution). Marine predators have been monitored as indicators of ecosystem change in the Southern Ocean. Understanding what determines the ability for an animal to dive is essential to elucidating its feeding ecology and important for answering broader ecological questions regarding ecosystem energy flow.

Metals in cetaceans in Greenlandic waters

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Pilot, killer and humpback whales and white-beaked dolphins have become increasingly more common in Greenlandic waters in recent years. All species, except killer whales, constitute part of the human diet in Greenland. We have analyzed metals in muscle from 12 humpback whales and four minke whales from west Greenland and nine pilot whales, 10 white beaked dolphins (WBD) and two killer whales from east Greenland. Eleven metals were analyzed including arsenic, cadmium, mercury, lead and selenium.

As expected, concentrations of mercury were highest in pilot and killer whales (up to 15,9 mg/kg wet weight (ww)). A maximum limit of methyl mercury in whale meat for human consumption is set to 0,3 mg/kg ww in Japan. All pilot and killer whales and 70% of the WBD had concentrations above 0,3 mg/kg ww.

Methylmercury can be detoxified by forming mercury selenide together with selenium in the liver. The ratio of Hg:Se on a molar basis can play an important role in an individual's health and a 1:1 relationship indicates an excess of mercury. In the present study, this ratio was between 0,012-1,70 (mean 0,46), indicating that there most often was an excess of selenium in relation to mercury. However, ten individuals had a ratio above 1 (all pilot whales and one killer whale).

Concentrations of arsenic were low and similar within the different species (0,11-0,68 mg/kg ww), with humpback whale showing the largest range and minke whale and killer whales had some of the lowest concentrations. Lead was below level of detection (<0,03 mg/kg ww) in all but two samples (WBD). Concentrations of cadmium were very low in all species except the pilot whales, where two had concentrations above 0,5 mg/kg ww, which is the EU recommended maximum level for cadmium in fish muscle for human consumption.

Predictors of breathing in migrating humpback whales (Megaptera novaeangliae)

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After diving, cetaceans must surface and breathe to replenish their oxygen reserves while offloading carbon dioxide. Changes in breathing behavior have been used as indicators of stress due to anthropogenic disturbance, however such changes could also be caused by natural factors. Humpback whales (*Megaptera novaeangliae*) have a breathing pattern typical of cetaceans. Their breathing behavior can be divided into two main aspects: 1) long dives with extended breath-hold, and 2) surface breathing bouts involving a series of relatively rapid breaths and shallow dives. The aim of this study was to determine the most important predictor variables for both breathing behavior components to better understand how a whale's breathing behavior can fluctuate according to its social and environmental context. A total of 40 migrating, adult humpback whales were tagged using digital recording tags (DTAGs) and focally followed from a land-based station and/or a small research vessel. Predictor variables measured included dive depth, swim speed, social context (e.g., number of males in the group), windspeed and water depth. Long breath-hold durations (>75 s), number of breaths in a breathing bout, and timing of breaths during a breathing bout were also measured. Two different modelling analyses were performed: one to explain the long breath-hold durations according to the predictor variables, the other to explain the breathing bout behavior. Preliminary results found that an increase in the number of males in the group (which was correlated with swim speed) shortened long breath-hold duration. This could be explained by increased energetic expenditure. This, in turn, influenced the breathing bout behavior: breath interval decreased with increasing preceding long breath-hold duration. This baseline information is necessary to

determine whether observed changes in humpback whale breathing behavior occur because of changes in a whale's natural context or anthropogenic disturbance.

Is the effect of noise mitigation during pile driving for offshore wind farms on the protection of harbour porpoises (Phocoena phocoena) overrated?

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All offshore wind farms (OWFs) built in German waters were accompanied by extensive passive-acoustic (CPODs) and aerial-survey-based monitoring programmes to assess potential adverse effects on harbour porpoises. Data collected during piling events of the period 2014-2016, when noise mitigation systems (NMS) reduced average broadband noise levels in 750 m distance to pilings to below 160 dB re 1 µPa²s (SEL_{05}), were compared with data of the period 2009-2013, when NMS were still under development and broadband noise levels in 750 m distance were on average 9 dB (SEL_{05}) higher. The aim of the study was to compare the efficiency of NMS during both periods regarding the effects of pile driving on harbor porpoises. CPOD and aerial-survey data revealed that porpoise density and detection rates were on average reduced in up to 15-17 km distance from pile driving, regardless of the period. Hence, no further reduction of the effect distance was found during the period 2014-2016 when compared with 2009-2013.

We a.o. hypothesise the following reasons which might have interacted to some degree: a) the seal scarer effect was stronger than expected and cannot be distinguished from the piling effect; b) porpoises exhibit a stereotypical initial response to pile driving and accompanied construction-related noise (e.g. vessel activities), so that a farther-reaching effect became visible only at very high piling-noise levels; c) stronger cumulative effects occurred during the period 2014-2016 due to tighter piling sequences; d) small-scale habitat differences among OWF areas led to heterogeneous response patterns.

Even though the results of this study still confirm a positive effect of NMS on harbour porpoises, the improvement of these systems seems to reach limits under the current construction procedures regarding the reduction of effect ranges of pile driving on harbour porpoises.

Clinical diagnostic advancements to better inform disposition decisions for live stranded small cetaceans

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Cape Cod, Massachusetts, USA is a global hotspot for live dolphin strandings, especially *Delphinus delphis* and *Lagenorhynchus acutus*. Faced with a lack of rehabilitation or short-term holding facilities, local stranding responders have relied primarily on physical examinations and point of care blood work to rapidly assess dolphin health and make appropriate disposition decisions within just a few hours. Starting in 2018, an enhanced clinical diagnostics project was undertaken in an effort to identify additional diagnostic tools to better inform disposition and treatment decisions for stranded small cetaceans. Additional diagnostic modalities included ultrasonography (n=32), capnography (n=50), electrocardiography (N=51), pulse oximetry (n=2) and blowhole cytology (n=22). An expanded reference laboratory clinical chemistry panel including fibrinogen and serum iron concentration as well as erythrocyte sedimentation rates were performed (n=45). Pulse oximetry and blowhole cytology were not found to be useful point of care diagnostics due to challenges of dolphin anatomy and field infeasibility, respectively. The most common ultrasound findings were mild pleural lesions, gas in the renal capsule and gas within the hepatic vasculature. End tidal carbon dioxide partial pressures ($ETCO_2$) tended to be inversely correlated with respiratory rate (increased $ETCO_2$ with decreased RR). Electrocardiograms showed sinus arrhythmias in most cases, although some animals lacked this normal respiratory-driven cardiac pattern. Animals that did not survive the stranding event or post-release commonly had thinner body condition and decreased alkaline phosphatase, a documented marker of inflammation

in managed care cetaceans, and were often stranded for a longer period of time than those that survived. The combination of case history, physical examination, point of care blood analyses, ultrasonography, capnography and electrocardiography was shown to be most useful for rapid in-field assessment to determine appropriate dispositions for live stranded small cetaceans.

The harmful effects of captivity and chronic stress on the well-being of orcas (Orcinus orca).
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Orcas are large, deep-diving cetaceans who are known for their global distribution, wide-ranging behavior, intelligence, and social complexity. They possess one of the largest and most complex brains in the mammalian kingdom. They are also the third most common species of cetaceans kept in aquariums and marine theme parks. Most spend many years, and sometimes decades, in captivity. At the time of writing, 63 individuals are held in concrete tanks globally.

The scientific data on how both wild-caught and captive-born orcas fare in captivity is increasingly robust in demonstrating that they cannot thrive under artificial circumstances in concrete tanks. In captivity, orcas exhibit a wide range of abnormal behaviors and often die at an early age from infections and other health conditions that are uncommon in a wild setting. Though numerous papers and reports describe these adverse effects, they do not offer a clear and systematic explanation for why captive orcas suffer chronic stress and how it affects their well-being.

We describe likely mechanisms for the high levels of morbidity and mortality in captive orcas, including the impact of chronic stress on the immune system, physiology and illness. We conclude that orcas are poor candidates for maintenance in captivity and suggest that a radical shift is required in their treatment, in order to meet their complex needs.

'Water, water, everywhere': Comparing marine mammal detections from eDNA with acoustic and visual data in the New York Bight.
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Environmental DNA (eDNA) analysis is an increasingly popular approach for surveying species occupancy, wherein DNA shed by organisms is recovered and identified from environmental sources such as samples of water or soil. While several studies have demonstrated that marine mammal eDNA can be detected, few studies have focused efforts in open ocean environments and incorporating multiple species assemblages. Here, we assess the efficacy of eDNA metabarcoding as a means for detecting marine mammals and their prey species in the New York Bight (NYB), an area that extends 16,000 square miles from Cape May, NJ, to Montauk, NY. Beginning in 2018, >200 water samples were collected during dedicated marine mammal sighting surveys and in proximity to acoustic deployments. Samples were taken at the time of a cetacean sighting as the animal sounded, and then again at the same location at specified time intervals. Water samples were also obtained at various time and distance intervals in proximity to acoustic recording devices in order to contrast eDNA and acoustic detections. The eDNA results to date have yielded positive detections for target species observed (e.g., Fin, Minke, and Humpback whales) at the time of sighting and within 30 minutes after sighting, along with co-localized presumptive prey species (both observed and non-observed, including Atlantic menhaden, family Clupeidae, and sand lance, family Ammodytidae). While the use of direct observation methods and passive acoustics for determining distribution and occurrence of marine mammals in the NYB remains essential, the development of complementary new approaches, such as eDNA assessments, also strengthens our understanding of habitat preference for endangered whales and dolphins and their prey. Integration of these approaches is increasingly important for establishing robust baselines on marine mammals and their prey amidst increasing anthropogenic activities in the vast NYB area, which includes

projected offshore wind development, shipping and exploitation of marine resources.

Singing in South Africa: Monitoring the occurrence of humpback whale (Megaptera novaeangliae) song near the Western Cape.
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Humpback whales (*Megaptera novaeangliae*) are highly vocal cetaceans, producing a wide repertoire of sounds including song, which is prolific at breeding sites. However, song has been increasingly reported from migration routes and feeding sites, including along the west coast of South Africa (28° to 34°S), a known migration route and feeding site for this species. Here we examine the occurrence of humpback whale song within False Bay from September 2016 – January 2018. Passive acoustic recordings from four locations were scrutinized for humpback whale vocalisations using long term spectral averages. In total, 7205 hours were examined, with song identified in 3% (211 hours) and being more prevalent at the most westerly sites. A strong temporal pattern was found with song exclusively documented in September and October 2016. Song was recorded during all hours of the day, however, a strong diurnal pattern was discovered with singing most common in the evening hours (21:00 to 23:00 pm). On 15 occasions, two or more singers were detected with temporally overlapping song components. These results indicate prevalent, albeit seasonal, song production by humpback whales off the coast of South Africa and highlight the utility of passive acoustic monitoring to indicate their presence and behaviour.

Citizen science as a tool for cetacean monitoring and conservation in the Gulf of Urabá, Colombian Caribbean
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Citizen science interconnects formal science - generated by academic institutions- and other stakeholders; promotes the knowledge and empowerment of local communities on the environment that surrounds them and allows them to obtain information in areas and times beyond the systematic monitoring of scientific programs. In the Gulf of Urabá, the Colombian Caribbean, the "Delfín Gris Project" characterizes the populations of dolphins that use the ecosystem, in terms of presence, abundance and habitat use to create conservation tools and face the environmental changes that are generated by the construction of three ports. One of the strategies to collect information and promote different social groups to familiarize with the dolphins is citizen science. In less than a year, the registration of 25 groups of five cetacean species has been made by fishermen, tour operators and the coastguard of the army. Through these records, the presence of three species that have not been reported before in the Gulf (*Stenella frontalis*, *Stenella attenuata* and *Delphinus delphis*) have been confirmed. I has also been possible to cover areas that do not include weekly monitoring of the project. These results-have a great importance considering that in project monitoring had only registered two species in the area (*Sotalia guianensis* and *Tursiops truncatus*), with a limited distribution only to the west region of the Gulf, and with a probability of sighting of less than 10% in the others areas within the Gulf. The success of this strategy of integrating the community, has generated that local organizations have joined efforts to learn about marine fauna, generate productive alternatives around them and to make new rules for anthropic activities that promote conservation.

Singing activity and song structure of breeding stock G wintering off the coast of Costa Rica and Panama
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Male humpback whales produce songs at their breeding areas presumably to attract females and compete with other males for access to females. These songs are composed of elements structured hierarchically and are population specific. Recent research shows that humpback whale song emission continues at their feeding areas. Thus, feeding areas that are used by whales from different breeding areas represent an opportunity for cultural transmission. Southern humpbacks migrate from feeding grounds in Antarctica to breeding grounds in Central America. Here we describe the acoustic activity and song structure of southern humpbacks breeding in Caño Island in Costa Rica and Secas, Coiba, and Perla Islands in Panama. Data was collected using multiplerecording systems including autonomous underwater recorders and recordings from the boat. After accounting for differences in recording effort, our results indicate that whale singing activity is significantly higher in Caño Island than in all Panamanian sites. In all sites whale songs were detected throughout the day, but in Caño Island there was a slight decrease between from 7 a.m. to noon. Singing activity peaked up in October for Caño, Secas, and Coiba. The song structure consisted of 13 unique units in Caño Island, 52 for Secas, 11 for Coiba, and 13 for Perlas. Only 12% of the units were shared among all sites. Within Secas the pace of annual theme change was slow with a rapid change between 2015 and 2017. Our results find considerable song unit differentiation between breeding areas in Costa Rica and Panama suggesting that these sites are probably used by males (at least some) from different feeding areas within Antarctica. If this is the case our results have important management implications. Future research will involve standardization of long-term recording methods between sites and expansion to include northern humpback whales migrating from California which are speculated to

Marine mammals vital rate estimation through a new regression approach

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Marine mammal populations are globally threatened but effective conservation requires detailed knowledge, especially on population vital rates such as survival and fecundity to assess the effects of pressures, both environmental and anthropogenic. Survival analysis can be undertaken either with (longitudinal) capture-recapture data or (cross-sectional) time-to-event (e.g. death) data. The latter design can used age data collected on stranded individuals to construct life-tables. We developed a flexible regression approach to estimate survival rates from stranding data, that allows for seamless incorporation and testing of covariates (e.g. sex effects). Our approach is parametric and models the hazard (i.e. instantaneous mortality rate) as a mixture of two components that may be interpreted as juvenile and adult hazards. The latter includes frailty (hidden heterogeneity). We implemented our approach in a Bayesian framework, using Hamiltonian Monte Carlo with software Stan. We carried out a simulation study to assess the performance of our proposed model, and to determine adequate sample size for estimating survival rates. This exercise revealed that sample size of 500 individuals were adequate and realistic for accurate estimation of survival rates. Our approach is promising for species where capture-recapture design are not feasible. Low data requirement and estimation effectiveness make our approach parsimonious and relevant in informing conservation policies. We illustrate it on harbour porpoise population (*Phocoena phocoena*) in the Bay of Biscay and Channel.

Incidences of netmarks on two dolphin species caught in bather protection nets along the KwaZulu-Natal coastline, South Africa (2010-2017)

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The Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and the Indian Ocean humpback dolphin (*Sousa plumbea*) are commonly found along the east coast of South Africa. Since 2009, detailed health investigations of the animals incidentally caught in bather protection nets along the KwaZulu-Natal coast have yielded a valuable dataset which allows for the assessment of netmarks, and evaluation if these can be used as reliable indicators of entanglement in stranded dolphins. Marine mammal dissection and necropsy reports as well as photographs of 125 animals known to have been caught in bather protection nets between 2010 and 2017 were investigated to determine prevalence of netmarks as well as any correlations with species, sex, age, and season. Our results showed that only 23.2% of the investigated

125 dolphins known to have died in nets presented signs of netmarks on the skin. There were clear differences between the two species, with only 13.8% of *Sousa* showing signs of netmarks, while 86.2% of *Tursiops* had netmarks. Furthermore, females were more likely to exhibit netmarks on the skin when compared to males (58.6% vs 41.4%). Adults were least likely to exhibit netmarks (31.0%), with the majority of dolphins being juveniles (69.0%; juveniles included calves, neonates and subadults). Seasonal differences were also observed, with more netmarks recorded in winter (37.9%), while summer appeared to have the least number of dolphins with netmarks (10.3%). This result was of particular interest as it contrasted with the assumption that increased temperature attributed to decay of dolphin carcasses and thus affected netmark occurrence. Netmarks and other injuries are considered to be a clear indication of entanglement. However, our study found that only a small percentage of bycaught animals actually present these signs of entanglement. Thus, other methods, in addition to netmark presence, are required to reliably identify entanglement cases in strandings.

Pollutants in polar bears from the Barents Sea – key drivers for spatial and temporal variation.

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Barents Sea polar bears are among the highest contaminated polar bear subpopulations within the Arctic. Polar bears from the Barents Sea have two distinct movement patterns to cope with seasonal variation of declining sea ice: "offshore bears" take long migrations to follow the ice towards the eastern Barents Sea, whereas "coastal" bears stay close to Svalbard yearlong. We investigated lipophilic persistent organic pollutants (POPs) in relation to space-use strategy in female polar bears from the Barents Sea. Offshore bears (n=92) had similar levels of POPs than the coastal bears, but they were fatter than the coastal bears. As POPs are more concentrated in thin bears, the effect of habitat use may be masked by body condition. A follow-up study selecting individuals with similar body condition from both groups (n=38) indicated that POP concentrations were higher in offshore bears. Analyses of compound-specific and bulk stable isotopes (δ15N and δ13C), home range location and field metabolic rate based on telemetry studies and contaminants in harp seals from different locations indicated that higher POP concentrations in offshore bears were related to higher proportion of marine and high-trophic level food items in their diet, higher energy requirements, their distribution in marginal ice zones and higher concentrations of pollutants in they prey. Furthermore, we assessed temporal variation of POPs in relation to changes in feeding habits and body condition in female polar bears (n=306) from the Barents Sea in 1997-2017. Analyses of δ15N and δ13C indicated a decreasing intake of marine and high trophic level prey items over time, whereas body condition had a non-significant decreasing tendency between 1997 and 2005, and increased significantly from 2005 to 2017. However, temporal trends of POPs in polar bears were largely controlled by primary and/or secondary emissions of POPs, and not changes in body condition and diet.Barents Sea

Comparative morphology of the spinal cord and associated vasculature in shallow vs. deep diving cetaceans.

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In cetaceans, the spinal cord and vascular supply for the entire central nervous system (CNS) lie within the vertebral canal. Unlike most terrestrial mammals, the cetacean brain is not directly supplied by carotid or discrete vertebral arteries, but instead by multiple intricate *retia mirabilia*. Thoracic and cervical *retia mirabilia* supply the epidural *rete mirabile*, which lies within the vertebral canal and feeds both the spinal cord and brain. The vertebral canal also contains the venous

components of the epidural *rete* and the veins that drain the CNS. Thus, the cetacean spinal cord lies within a highly derived, vascularized space within the vertebral canal. Our goal is to examine the relative sizes of these structures across cetacean species that display differences in diving ability. We ask whether (1) the size of the spinal cord, a metabolically expensive tissue, will be relatively smaller in deep *vs.* shallow diving cetaceans, and (2) vascular structures within the vertebral canal of deep divers will occupy a greater relative cross-sectional area than in shallow divers, because of their larger blood volumes. We section whole frozen vertebral columns at each intervertebral disc, take scaled photographs of the vertebral canal contents, and digitally measure areas of all structures in Image-Pro Plus. We are investigating the shallow diving *Tursiops truncatus*, intermediate diving *Delphinus delphis*, and deep diving *Kogia breviceps*, *Mesoplodon europaeus*, and *Ziphius cavirostris*. Preliminary analyses at a mid-thoracic vertebra (T5) demonstrate that in *Z. cavirostris*, the vascular tissues represent 97%, and the spinal cord 2%, of the vertebral canal cross-sectional area. In *T. truncatus*, these values are 86% and 10%, respectively. Thus, in both shallow and deep divers, the thoracic vertebral canal is predominantly a vascularized space. We will describe how these structures vary, both absolutely and relativey, along the length of the vertebral column and across species.

Health parameters of common bottlenose dolphins (Tursiops truncatus) in various salinity environments within the Barataria Basin, Louisiana

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As part of a study to establish baselines of common bottlenose dolphin movements in various salinity gradients within the Barataria Basin, Louisiana, veterinarians conducted dolphin health assessments that included physical examination and skin assessment. Sample collection included blood for hematology and serum chemistry, tissue biopsies for histology, and serum/plasma/urine for osmolality. Pulmonary and reproductive ultrasound were also performed to provide further insight into individual animal health. Dolphins were sampled in two time periods in which salinity differed: June 2017 (salinity ranges at the site of capture = 0.7-10.2 ppt) (N = 13) and September 2017 (salinity ranges at capture = 17.7-20.3 ppt) (N = 22). Hematology and serum chemistry data were organized into panels representing organ systems or pathologic processes, and abnormalities were identified by comparing panel parameters with established reference ranges. Nonetheless, a high prevalence of skin lesions was identified, as well as abnormalities in serum biochemical markers and urine:serum osmolality ratios for dolphins sampled in the more northern (and lower salinity) portions of the basin. Unfortunately, this study was not designed to assess the dolphins' health after prolonged exposure to low salinity. Evidence from peer-reviewed literature and field studies suggest that continued exposure to low salinities may lead to adverse health effects. A synthesis and analysis of records using a standardized approach for assessments will be valuable in determining the long-term impacts of low salinity exposure in both natural events (e.g. extreme weather) and anthropogenic events (e.g. trapped behind levee construction). This project was funded through the Gulf Environmental Benefit Fund, National Fish and Wildlife Foundation.

A variable policy landscape for protecting marine species during offshore wind development

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The offshore wind energy sector in the United States is growing rapidly. The existing leases and planning areas for offshore wind development on the Atlantic Outer Continental Shelf (OCS) also coincide with important areas for marine protected species. While U.S. federal laws, the Marine Mammal Protection Act and the Endangered Species Act, are designed to ensure that offshore wind development does not negatively affect marine protected species, regulators and stakeholders are oftentimes not always approving developer plans prior to survey operations. As a result, wind energy companies can hold multiple permits and communications in relation to marine species monitoring and mitigation, which can ultimately lead to conflicting information between documents. From a Protected Species Observer (PSO) perspective, this can lead to confusion among vessel personnel during on-water operations, and lack of protection for marine

mammals. Our research suggests that on- water operations would benefit from a mitigation hierarchy, directed by Federal agencies, that allows for adaptability while ensuring environmental responsibility is upheld by all personnel from management to deckhands. In addition, our research demonstrates that the lack of standardized monitoring procedures, methods for recording data, and sharing of data continues to be inefficient for PSO operations. The transparency of data collected during offshore activities is essential for better understanding the impacts of activities on marine species, and to fill in data gaps on species distribution and behavior. This poster will present our findings in support of the following recommendations: 1) a single, industry wide PSO datasheet that is easily transferrable, 2) A "Notice to Leases" for the Atlantic OCS similar to that of the Gulf of Mexico, 3) a public data repository that would benefit scientists, policy makers, and marine protected species research, and 4) a requirement for comprehensive training opportunities for PSO professionals.

Effect of rehabilitation on the distal gut microbiome of stranded harbour seals (Phoca vitulina)

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The Sealcentre Pieterburen, the Netherlands, rehabilitates stranded harbour (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). Most seals stranded on the Dutch coast are orphaned pups or young seals with parasitic pneumonia that are admitted to the Sealcentre with critical health status. Different aspects during the rehabilitation process such as feeding, water and environment may affect the gut microbiome of the seals. Therefore, we investigated the distal gut microbiome of the seals before and during rehabilitation using 16S amplicon next generation sequencing.

During summer 2015 and winter 2015-2016, rectal swabs were collected from 200 harbour seals that were admitted for rehabilitation to the Sealcentre. Samples were collected at admission, during rehabilitation (days 8 and 15) and just before release. Seals that died were sampled during postmortem examination. Here we present the changes observed in the microbiome of seals that did not receive antibiotic treatment during their rehabilitation.

From all swabs collected, DNA was isolated and amplicon sequencing was performed using Illumina Miseq 2x300bp sequencing of 460 bp of the 16S V3–V4 region. Reads were analyzed using DADA2. Alpha and beta diversity were determined using Phyloseq and tested for significant differences between sample groups adjusting for confounders using Linear Mixed-Effects Models and PERMANOVA.

The distal gut microbiome of harbor seals at the rehabilitation center was primarily composed of bacteria of the phyla Firmicutes, Fusobacteria, Bacteroidetes, Proteobacteria and Gracilibacteria. We observed that age, duration of stay in rehabilitation, change from milk to salmon feeding and the individual itself had a large effect on alpha diversity. In addition, rehabilitation did not result in a lower alpha diversity. However, beta-diversity differences were observed between the microbiome of wild animals and rehabilitated animals.

Cetacean morbillivirus in Spanish Mediterranean Sea: Update.

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Cetacean morbillivirus (CeMV) has caused thousands of deaths in cetaceans worldwide. The first known outbreak happened in 1988 on the USA's Atlantic coast. Since then, different outbreaks have affected cetacean populations in the northern hemisphere, especially in the Mediterranean and on the Atlantic coast of the USA. In Mediterranean Sea, two important outbreaks affected to striped dolphin population, first one was in 1990 and second in 2007. Both of them started at the same location, in Valencian Community coast (Spanish Mediterranean Sea).

Therefore, this zone has been transformed in an important place for better understanding of CeMV epidemiology. Since 2010 all cetaceans that have stranded in Valencian Community coasts have been analyzed for CeMV. In 2011, we identified a third outbreak of CeMV in western Mediterranean Sea that affected to 50 striped dolphins in only two months. Sequence that was found in all positive animals were phylogenetically close to 2007 CeMV outbreak sequence. Additionally, since 2012 to present we have detected that a novel sequence of CeMV is circulating in Mediterranean striped dolphin population and has an Atlantic origin. We have identified this novel sequence in 5 striped dolphins and one common dolphin from Western Mediterranean coast. In this work we review the current state of knowledge on CeMV in western Mediterranean Sea and epidemiology of the disease.

Blue whales off the Southern coast of Sri Lanka during the Southwest Monsoon Season.

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Observations of 37 individual blue whales (*Balaenoptera musculus*) were recorded off the southern coast of Sri Lanka during the Southwest Monsoon Season (SWM). Sightings were made during a scientific geophysical survey campaign conducted in July and August 2017. Whilst blue whales are regularly recorded on the continental slope of southern Sri Lanka during the Northeast Monsoon Season (NEM) (December - March) and during the two inter-monsoonal periods (March - April and September - October), limited data is available for the SWM (May - September) mostly due to unfavourable weather conditions and very little survey effort. In the northern hemisphere, blue whales undertake seasonal migrations from higher latitude feeding grounds to lower latitude breeding and wintering areas. However it has been suggested that a population of blue whales in the Northern India Ocean (NIO) remains in lower latitudes year round taking advantage of the rich upwelling areas off Somalia, southwest Arabia and western Sri Lanka. Data from this study nevertheless support a theory that a certain number of individuals remain off the southern coast off Sri Lanka during the SWM, suggesting that the productivity in this region is sufficient to support their year-round presence. This study therefore fills a knowledge gap regarding the presence and movement of blue whales in the NIO highlighting the importance of data obtained from platforms of opportunity.

Four decades of stranding response: Hotspots, coverage gaps, and shifting baselines in North central Gulf of Mexico.

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Cetacean stranding data from Alabama (AL) in the northern Gulf of Mexico (nGOM) have been recorded since 1978, with dedicated stranding response beginning in 1987. Currently, no publications summarize historic and modern stranding trends in this state, which connects the eastern and western nGOM coastlines. To define long-term stranding patterns, we analyzed available Level A data collected in AL between 1978 and 2018, stratified by stranding response agency to account for variation in response effort through time. From 1978-2018, 788 stranding events were recorded involving at least 13 different cetacean species. Bottlenose dolphins (Tursiops truncatus) were the most commonly reported stranded cetacean in AL (n=683, 87.9%) followed by Stenella spp. (n=32, 4.1%). Most strandings recorded during this forty year study occurred on Dauphin Island, Fort Morgan, and Orange Beach, indicating specific stranding hotspots in AL. Three unusual mortality events (UMEs) occurred in the nGOM during this period: 1990, 1993, and 2010-2014 with increased strandings in AL (n=61, 48, 169, respectively). Mean annual stranding numbers during years of dedicated response from 1987-2006 were 20.1 strandings per year. In 2007 and 2008, there was a response agency coverage gap, reflected in low stranding numbers with an average of 4.5 strandings per year. During the 2010-2014 nGOM UME, there were 36.2 average annual strandings. Post-UME stranding values remained elevated from 2015-2018 with 39.1 average annual strandings. The elevated annual averages in years after the 2010-2014 UME compared to mean stranding numbers before 2010 indicate a possible shift in baseline stranding trends for AL, potentially due to a combination of increased strandings after the Deepwater Horizon Oil Spill in 2010 as well as increased awareness and effort by area responders. The examination of historical and modern stranding demographics will allow for more focused stranding response and evaluation of changing trends in the nGOM.

Photographic identification of beluga whales in Cumberland Sound, Canada.
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Photographic identification is a valuable tool in the monitoring and management of at-risk marine mammal populations, providing insights into their movements, site fidelity, social structure, and reproductive history. The isolated beluga whale population in Cumberland Sound, Baffin Island, Nunavut, was commercially exploited for several decades until the 1960s. The population was reduced from over 8,000 whales to its current size of approximately 1,400 whales, and it is still harvested by the local Inuit community Pangnirtung at a rate of 41 whales landed per year. Consequently, it has been listed as threatened (COSEWIC and SARA). The objective of our study was to develop a catalog for future analyses, including a capture-mark-recapture technique to estimate population abundance. Photographs of belugas were taken in August 2017 and 2018 using a DJI Phantom 4 drone and supplemented with boat-based photographs in 2018. Whales were identified using scars from natural sources and from hunting wounds. Analyses of the 2017 images indicate that approximately 36% of the population is marked and at least 43 whales were photographed with markings that appeared to be unique and likely to persist over long periods of time. Four whales were photographed and identified in both 2017 and 2018. Group sizes ranged from 1-16 whales with an average group size of 3.7 whales. Approximately 70% of the population were classified as adults, 16% as juveniles, 7% as calves, and the remainder were unknown; these classifications were made based on color, size, and proximity to adults. Creating a photographic identification catalog for this population will allow us to infer life-history characteristics (e.g. calving rate and survival) which is needed for understanding population growth and for monitoring the population. Gaining a better understanding of the Cumberland Sound beluga whale population demography will allow for the development of more effective conservation and management strategies.

Florida manatee behavioral response to boats
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The Florida manatee (*Trichechus manatus latirostris*) is a threatened species which suffers substantial mortality from collisions with boats. To better understand the causes of manatee-boat collisions, we combined advanced tag technologies with boat-based focal follows to document the behavior of manatees in response to opportunistic vessel approaches. Argos-linked GPS tags and digital acoustic tags (DTAGs) were deployed on 18 manatees in southwest Florida, providing high-resolution data on manatee location, depth, heading, fluking, and orientation. This permitted a multi-dimensional reconstruction of the manatee's movements and behavior in relation to the trajectories and sounds of passing boats. We built generalized linear mixed models to determine which boat, manatee, and habitat factors accounted for variation in the occurrence, type, and timing of manatee behavioral responses during boat passes. Manatees displayed significantly higher rates of change in roll, heading, depth, and fluking behavior during boat passes <50 m than during periods in which boat noise was absent. Manatees changed their behavior in 89% of cases in which the boat passed within 10 m, significantly higher than during more distant passes. Manatees were more likely to change depth if they were actively fluking or not on a seagrass bed. Boat speed did not affect the occurrence or intensity of manatee response. However, the timing of a manatee's change in behavior relative to an approaching boat was influenced by boat speed; slower boats allowed the manatee more time to respond and behavioral change occurred earlier relative to the time of the boat's closest point of approach. Our findings indicate that fast-moving boats likely pose a greater threat to manatees than slower boats.

Risso's dolphins (Grampus griseus) as an indicator species for the monitoring plan of the Cabrera Archipelago National Park, the largest marine National Park in the Mediterranean Sea
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In February 2019, Spain upgraded Cabrera National park to a total extent of more than 90.000 hectares, mainly offshore from the original Park created in 1986. One of the main features protected by this extended MPA is the Emile Baudot Escarpment, which offer a unique foraging habitat for species feeding on deep sea cephalopods. The Risso's dolphin (*Grampus griseus*) is known to feed on mesopelagic squid over areas with steep bottom topography and is one of the most commonly observed predators in the region.

Monitoring a large offshore MPA poses a series of logistic and economic challenges. After being involved in collecting data that has contributed to the declaring of this National Park, the research organisation Alnitak is now focused on ensuring the long-term monitoring through EMS[1] and the use of indicator species such as the Risso's dolphin. In this study we present the results of the development of an "open source" photo identification catalogue for Grampus griseus hosted at the Organismo Autónomo de Parque Nacionales (OAPN), which is the managing body of the upgraded area.

In addition to a schedule of 4 dedicated surveys per year in all seasons, we present a citizen science APP that should allow the input of images by opportunistic observers, thus contributing to our database and supporting the determination of baseline information to provide recommendations on management and conservation.

Macro-litter in stranded cetaceans in North-eastern Portugal

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Marine litter is presently recognised as a global anthropogenic threat to marine and costal environments impacting hundreds of marine species, through entanglement and ingestion. Entanglement or ingestion were already reported in 58% of all cetacean species, and consequences of these encounters include internal and external injuries, drowning and limited predator avoidance capabilities, impairment of feeding ability, blockage of the digestive tract, starvation and death.

We present macro-litter ingestion/entanglement frequency of occurrence (F.O.) rates in cetaceans found stranded in the north-central coast of Portugal, collected by the national marine mammal stranding network since the year 2000. For Mysticetes (n=76), only one case of ingestion was recorded (F.O.=1,3%), on a Minke whale (*Balaenoptera acutorostrata*). Considering Odontocetes (n=2232), marine litter including different plastics and derelict fishing gear was registered on 13 species, with variable frequencies of occurrence. Although the overall rate of ingestion/entanglement was equally 1,3%, when considering only animals with marine litter, Pygmy sperm whales (*Kogia breviceps*) showed the highest F.O. (33,3%), followed by Sperm whales (*Physeter macrocephalus*) with 28,6%. Rates of ingestion/entanglement in cetaceans could be influenced by each species' behavioural and feeding habits (deep diving, bottom or pelagic feeders) and by sample size. In terms of mortality rates, plastic ingestion or entanglement as cause of death was attributed to one Sperm whale, one Pygmy sperm whale and one Common dolphin, corresponding to 10% of all cetaceans registered in the present study that interacted with marine litter through ingestion/entanglement (n=30) and to 0,13% of all stranded cetaceans. It is important to note that marine litter reported from stranded animals represents only a portion of the overall affected marine animals, so the presented ingestion/entanglement rates are surely underestimated. Also, on-going studies on microplastic ingestion should disclose more severe impacts of marine litter on cetaceans stranded in Portugal.

Revealing former sperm whale distribution in Indonesian waters based on historical whaling data using habitat models

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Knowledge on the presence and habitat preference of species are important for conservation purposes. However, in Indonesian water records of animal occurrence that cover vast areas are lacking. The most abundant available record concerns historical whaling data for sperm whale. In 1935, Charles Haskins Townsend recorded sperm whale captures from 1761-1930, a species that is ubiquitous around equatorial Indonesia. However, since Townsend only depicted the points where whaling occurred, the information on their distribution and seasonal movement pattern were never available. This study aims to assess the former sperm whale distribution and seasonal movement patterns by applying known sperm whale habitat preferences to the whaling historical data. This is done using a presence only habitat model Maximum Entropy (Maxent), and Generalized Additive Model (GAM) with nine submerged topographic variables. Maxent predicted a wider area of distribution than GAM, and its distributions agreed best with the whaling sighting data. We found that distance to coast, distance to -5000m depth contour, and submarine key features such as trough and trench are important variables that characterises sperm whale habitat. The results firstly show that in four areas in east part of Indonesia no seasonal differences occur in sperm whale distribution, while noticeable seasonal differences in distributions were observed in other areas. This historical distribution can be a baseline in assessing present sperm whale distribution. Our study demonstrates the benefits of incorporating unconventional datasets such as historical whaling data into species distribution models to inform conservation management of cetaceans.

Behavioral development of infant carrying behavior in captive Commerson's dolphins

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Infant carrying behavior is vital for cetacean mother and calf dyads as it provides protection from predators when foraging with an undeveloped neonate. We investigated the development of infant carrying behavior for Commerson's dolphin (*Cephalorhynchus commersonii*) in Toba aquarium, Japan. We recorded the dyad's position (e.g., echelon, infant, other position during pair swimming or solo swimming), and defined infant carrying as the mother engaging in stroking behavior more frequently than a calf during 3 second period. We also video-recorded and analyzed distance per stroke (DPS) during echelon position and solo swimming. A male neonate and its mother were observed from day of 5 to 199 after birth, for 16 days in total. About 30% of the observation time the dyad adopted the infant position throughout the study period. During day 5, the dyad adopted the echelon position most frequently (52%), with preference for this position declining gradually over time. In contrast, solo swimming increased up to 50% by day 107. Infant carrying was observed 29% of the time on average during the first month, and declined during and after the second month (< 10%). Video analysis revealed that DPS of the mother during echelon position was 43% (1.2m) comparing to its solo swim (2.1m). On the other hand, DPS of the neonate was 1149% (7.4m) comparing to its solo swim (0.6m) in day 6. DPS of the neonate during echelon position decreased drastically in the second month (2.7m, 338% of solo swim (0.8m)) and the third month (2.0m, 154% of solo swim (1.3m)). These results suggest that infant carrying behavior occurred mainly in the first month. Quantity and quality of infant carrying behavior might change depending on a calf's swimming ability and physical development.

Putting passive acoustic data to work: Developing a standardized, open-source approach to automated analysis of passive acoustic data.

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Passive acoustic monitoring has shown great potential for cetacean population assessment, including density estimation and habitat modeling. This requires competence in cetacean detection,

classification, and localization, but this potential has been impeded by unreliable species classification, manual data processing, and a lack of integration between acoustic data and other critical ancillary data. Additionally, a wide variety of tools are available and researchers have generally pursued different approaches to the processing and analysis of acoustic data, severely limiting the reproducibility and comparability of results. Here we present a series of Free Open-Source Software packages for Acoustics (FOSSA) that can be used to efficiently process and analyze passive acoustic data. Built in R, FOSSA currently consists of three packages: (1) functions to extract data from acoustic detections, integrate it with ancillary data (e.g. visual and environmental), generate summaries, and output data for downstream analyses (PAMr, in beta testing), (2) a powerful and systematic method for cetacean species classification using passive acoustics (BANTER, complete), and (3) a package for the coordination of acoustic cetacean population assessment tools (PAMde, in development). These are currently designed to work seamlessly with acoustic data collected and analyzed with Pamguard software, but their utility will apply broadly to a variety of acoustic data. A key goal of FOSSA is modularity and flexibility - technology is rapidly evolving, so these packages are designed to allow users to easily incorporate new techniques with minimal effort. Ultimately, the analytical advancements provided by PAMr, BANTER, and PAMde will allow for efficient, standardized results that can be quickly produced with minimal human intervention. FOSSA, as well as supporting data and training materials, will be made publicly available.

How U.S. laws work to protect and recover endangered marine mammals.

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The United States has powerful marine mammal and endangered species laws that reduce threats and promote the recovery of marine mammals. We will provide a clear description of how the U.S. Marine Mammal Protection Act and Endangered Species Act work. We will also provide some comparisons to European laws.

We will discuss the recovery of endangered marine mammals in the United States. The Endangered Species Act is the most powerful wildlife law in the United States, and it has successfully prevented the extinction of 99% of species listed under the Act. Using U.S. marine mammal stock assessment reports, species recovery plans, five-year status reviews, and primary sources from peer-reviewed scientific journals, we quantitatively analyzed population trends for 37 marine mammal populations within U.S. jurisdiction since listing. We found that 18 marine mammal (78%) populations significantly increased after gaining legal protections.

We will describe how conservation measures triggered by Endangered Species Act, such as ending exploitation, tailored species management, and fishery regulations, and other national and international measures, appear to have been largely successful in promoting species recovery, leading to the delisting of some species and to increases in most populations.

Finally, presenters will illustrate the benefits and shortcomings of the U.S. marine mammal and endangered species laws to address threats to marine mammals. We will also describe the threats to these bedrock environmental laws, and what is being done to secure these important conservation tools.

Three-dimensional hierarchical prey search behavior of lactating northern fur seals

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Marine prey are often distributed hierarchically, wherein small, high-density patches are nested inside larger, lower-density aggregations three-dimensionally. Marine predators usually adjust their movements according to the hierarchical distribution of their prey, and their adjusted movement often appears as area restricted search (ARS). The foraging behavior of lactating northern fur seals (Callorhinus ursinus; NFS) can be defined on three time scales, a single dive, a succession of dives (a bout), and the foraging trip (one or more dive bouts). Previous studies examined bout- and trip-scale ARS in two dimensions. Here, we used spherical first passage time (SFPT) to detect volume-restricted search (VRS, term for 3D ARS). We aimed to examine VRS behavior in a single

dive-scale and bout-scale by using SFPT. In 2006, four lactating NFS were instrumented with GPS and 3D data loggers and recovered after 1-3 foraging trips. We reconstructed 3D dive paths by using depth, tri-axis acceleration, tri-axis magnetometry and swim speed. We identified the spatial-scale of VRS using SFPT analysis on 3D paths of the bottom phase in each dive and for dive bouts during each night. We used vertical turns considered as a prey encounter index to examine to foraging effort during each dive. VRS scale for individual dives (small VRS) was 4-5 m in diameter and VRS scale of dive bouts (large VRS) was 32.4±5.8 m. Of all dives for each seal, 22.1±6.0% were dives with small VRS. However, vertical turn rate did not differ between dives with and without VRS. Large VRS included both dives with and without small VRS. Therefore, it appears that searching on the dive bout scale is important in NFS foraging. In the future, we should pay attention to bout-scale behavior to examine foraging efficiency of NFS during foraging trips.

Plasticizers and flame retardants in dolphins from the Mediterranean Sea.

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The present study investigates the occurrence of halogenated and organophosphate flame retardants (HFRs and OPFRs) in blubber of 8 individuals of endangered common dolphins (*Delphinus delphis*) from the Alboran Sea (Mediterranean Sea). HFRs are applied to materials to increase their fire resistance. Polybromodiphenyl ethers (PBDEs) are the most used HFRs and can be found in plastics, furniture or electronic devices. OPFRs are a large class of FRs, which are also used as plasticizers. Both HFRs and OPFRs are endocrine disruptors affecting thyroid glands and some reproductive functions and can cause neurotoxic effects. OPFRs were also suspected carcinogens affecting liver, kidney and testes tissue. PBDEs were detected in all individuals at concentrations ranging from 93.3 to 2045 ng/g lipid weight (lw), with a mean value of 1050 ng/g lw. OPFRs were also detected in all the samples with total concentrations between 151 and 2159 ng/g lw, with a mean value of 1146 ng/g lw. If we take into account that OPFRs represent around 15% by volume of the FR total global production, whereas HFRs represent around 30% by volume, the environmental occurrence of HFRs should be something higher. Moreover, higher bioaccumulation potential of HFRs versus OPFRs has been previously described, as well as limited OPFR biomagnification through food web probably due to biotransformation processes. All these data suggested that HFR levels in dolphins, with a high trophic level, should be higher than those of OPFRs. Thus, the similarity on the range of concentrations for both groups of pollutants could indicate an additional OPFR source of pollution in addition to their use as FRs. Precisely, the OPFR use also as plasticizers, as well as the large amount of marine plastic debris could contribute to the OPFR levels found in dolphin tissues.

The ACCOBAMS certification for highly qualified Marine Mammals Observers.

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During their Sixth Meeting in 2016, Countries member of the ACCOBAMS expressed the importance of providing a standardized training programme for Marine Mammals Observers (MMOs) and Passive Acoustic Monitoring (PAM) Operators operating during human activities generating noise. In this context, a Resolution was adopted in order to guarantee, throughout the Agreement area, a high-quality standardized training of MMOs/PAM.

The aim was to propose recognized and credible certification with standard training for the whole ACCOBAMS area. In this context, ACCOBAMS countries are encouraged to give permits, in priority, to industrial companies employing Highly Qualified MMOs/PAM operators.

In 2018, the ACCOBAMS Permanent Secretariat, with the assistance of the « ACCOBAMS MMO/PAM Courses Committee», finalized the standard high level course material. This material was provided to the three current accredited "ACCOBAMS highly qualified MMOs/PAM operator" trainer organizations, that will be responsible for running the training in the ACCOBAMS Area (to date: Blue world Institute, Oceanomare Delphis Onlus and DMAD).

Most of the measures proposed to be implemented in the ACCOBAMS area are standard, with some peculiarities including a more conservationist approach and an adaptability: *i.e.* the mitigation zone should be defined on site with in-situ measurements and take into account the level of noise that is known to be harmful to cetacean

species based on more recent knowledge, and should be expanded for behavioural impacts.

The first ACCOBAMS training for High Quality MMO/PAM Operator has been carried out by ACCOBAMS in Constanta, Romania (12 to 16 September 2018). Twelve trainees from five countries of the Black Sea undertook the training provided by four relevant experts and professional MMO/PAM operator. Subsequent trainings will be delivered by accredited "ACCOBAMS highly qualified MMOs/PAM operator" trainer organizations. For more information see the website "Netccobams.com".

Agonistic behaviour between breeding females of the northern elephant seal (Mirounga angustirostris) at Islas San Benito, Mexico.

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Agonistic behaviour between individuals of the same sex is generally related to individual reproductive success. It has been studied widely in male pinnipeds, where it determines access to territories or females. Agonistic behaviour also occurs between females, for example to protect pups or defend space at the breeding site, but has been studied little, particularly in phocids. We investigated aggression between breeding females of the northern elephant seal (*Mirounga angustirostris*) to determine its characteristics and functions and to document the relationship between aggression and female characteristics (e.g. body size) and social environment (e.g. harem size). We studied seals at the southern breeding colony at Islas San Benito, Mexico, during the breeding seasons of 2006-2007 and 2007-2008. We observed >5500 interactions between females in >1100 hr of observation. We found that most directed agonistic behaviour was between nursing females, not pregnant ones, and that it varied in relation to body size but not to characteristics of the social unit, such as harem size or operational sex ratio.

Humpback whale calves' vocal repertoire in the Sainte Marie channel breeding ground.

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Humpback whales use vocalizations during diverse social interactions or to organise activity such as foraging or mating. Unlike songs, which are confined to males, social calls are involved in social interactions, and have been reported to be produced by all types of individuals, adult males and females, juveniles and calves alike. Recent studies have described these social calls in different geographic areas; however, the context and biological functions of these social calls remains unknown. This study, aims to investigate the vocal repertoire of humpback whale calves during interactions with their mothers. We recorded mother-calf vocal activity during the breeding season in Madagascar by using Acousondes tags attached to mother-calf pairs (either mother or calf or both). Based on a previous description of the vocal repertoire of social sounds in the study area, we were able to identify 9 types of calls by calves, varying from low to mid-frequency, including one call presenting amplitude modulation. Two of the calves' vocalizations reported in this study were similar to calves' vocalizations described in the literature of other geographic areas, and four call types appeared to be group-specific. Though humpback whale calves' vocalizations are in general relatively simple in structure, we found that calves are also able to produce combined calls, composite calls and sequenced calls. Such diversity in call production may be part of the vocal ontogeny of humpback whales, and could lead to a more stable and complex vocal repertoire at adulthood.

The 'Glider and Whales' project: How to explore occurrence and distribution of whales in the Indian Ocean using acoustic glider.

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In this project named 'Gilder and Whales' an autonomousglider SEAEXPLORER equipped with one hydrophone was used tostudy marine

mammals by listening to the sound they produce, through 3 missions in the Indian Ocean (IO). The glider's speed was close to 0.5 knots, which was slow enough to ensure a good listening quality. It embedded several equipment for positioning, communication and data transmission, and for oceanographic monitoring (pressure, temperature, light)to describe the oceanographic habitat in which the detected animals live. In May 2017, the glider made its first mission in the western part of the Indian Ocean to explore the south of Madagascar in the southeast of Walters Shoals. During 10 days, it traveled nearly 200 km and continuously collected acoustic data with a sample rate of 32 kHz as well as environmental data. In February – April 2018, the glider made two other missions of 17 days each, to explore the eastern part of the Indian Ocean and specially waters around Amsterdam and Saint Paul islands. Through these 3 missions, the glider collected more than 500 Go of acoustic data. Among them, calls, songs, echolocation clicks and whistles produced by different cetacean species including Antarctic blue whales, Madagascar pygmy blue whales, fin whales, sperm whales and dolphins had been manually detected. Detection of cetacean sounds were analyzed to assess the temporal distribution and mapping of species in the studied areas, the time of the days when detection occurred and the ocean depths where acoustic encounters were recorded. This project could attest the capability and the efficiency of the glider technology for cetacean study and highlights how the glider provides a useful alternative to fixed passive acoustic monitoring to explore remote areas.

Killer whale dietary preferences during a period of contrasting availability of prey resources.

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In the North Atlantic, killer whale occurrence is generally related with the spatial distribution of lipid rich fish species. In Norway and Iceland, killer whales appear to specialise on herring although this dietary preference may be seasonal. Indeed, in the Norwegian Sea, killer whales associated with mackerel but not herring in the summer. In Icelandic waters, mackerel has been increasingly observed in the summer and currently greatly surpasses the estimated stock size of the Icelandic summer-spawning (ISS) herring, which has been declining. Whether herring-specialist killer whales switch from a preferred herring prey to mackerel in this context remains to be tested. Given the similar trophic position and diet of herring and mackerel, it is difficult to test dietary preferences for either prey using standard chemical tracer analyses of killer whale tissues. Thus, we investigated spatial associations with both fish species by conducting marine mammal observations onboard the International Ecosystem Summer Survey in the Nordic Seas taking place in offshore Icelandic waters in July 2015 and 2017. Simultaneously, we monitored killer whale occurrence and feeding behaviour in an inshore herring spawning ground, Vestmannaeyjar. Killer whale sightings in offshore regions (n_{2015} = 15 and n_{2017} = 2) suggested more likely associations with herring catches than mackerel. In inshore herring spawning grounds, killer whales occurred regularly (19 days with killer whale sightings in 2015 and 10 days in 2017) and were observed feeding on herring. These results suggest preferential feeding on herring, despite decreasing prey availability and increasing availability of an alternative resource. This may be because prey requirements are being met even under the current decreased stock levels or because strict prey specialisation, as seen in other populations, constraints diet switching but future work will be required to estimate the prey stock size required to sustain this population.

Dietary preferences of Tursiops truncatus and Globicephala macrorhynchus in Madeira Archipelago (NE Atlantic) inferred from fatty acids of biopsy samples.

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The common bottlenose dolphin (*Tursiops truncatus*) and the short-finned pilot whale (*Globicephala macrorhynchus*) occur year-round in the waters off Madeira Archipelago, and present island-associated populations, yet no literature is found about their diet composition in this region. Bottlenose dolphins are usually opportunistic feeders inhabiting coastal waters, but oceanic groups also occur offshore. Pilot whales inhabit offshore deep waters, with a diet based almost exclusively on cephalopods, but encounters of inter-specific mixed groups are very frequent in Madeira and are likely explained as occasional foraging associations. Analysis of fatty acids (FAs) profiles has been revealed as a powerful technique for quantitative and qualitative assessments of cetaceans' diet. This method is based on the principle that FAs are transferred almost unmodified from the prey to the blubber of the predators. Following this approach, we analised 34 different FAs in order to obtain fine-scale profiles from blubber samples of free-ranging bottlenose dolphins (n=30) and short-finned pilot whales (n=30), and compared them with those from samples of the three most abundant small pelagic fish species in the region (*Scomber colias*, n=15; *Trachurus picturatus*, n=18; *Sardina pilchardus*, n=16), and squids (*Sthenoteuthis pteropus*, n=6; unidentified squid, n=5). Samples collection occurred year-round in 2017-2018, covering all seasons. This is the first study aiming to clarify diet composition and seasonal dietary preferences of these top-predator key species in Madeira Archipelago, using fatty acids analysis, and discussing trophic relationships among these two species. The results are showing us which are the predominant prey species and also if there is a shift in prey abundance in the study area. This knowledge is crucial when implementing conservation measures for these protected species of cetaceans and in the management of the fishery activity in the archipelago, given the commercial relevance of these prey species in the region.

Morbillivirus infection and fishing interaction affecting cetacean species in the Paraná state, southern Brazil.

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Cetacean morbillivirus (CeMV) causes epidemics fatalities worldwide. Three strains are characterized (DMV, PMV and PWMV) and a novel strain Sotalia guianensis-CeMV was described in Brazil. Interactions between fishing and morbillivirus might accumulate effects increasing population vulnerability. To investigate the occurrence of CeMV and identify possible fishing interaction in cetaceans off Paraná coast. Since September/16, 51 dead stranded cetaceans recorded by the Projeto de Monitoramento de Praia da Bacia de Santos* (PMP-BS) - a monitoring program required by Brazil's federal environmental agency, IBAMA, for the environmental licensing process of the oil production and transport by Petrobras at the Santos Basin pre-salt province (25°05'S 42°35'W to 25°55'S 43°34'W) - were necropsied. From 25, lungs and central nervous system (CNS) samples were collected to histological and immunohistochemical (anti-CeMV) evaluation. Species stranded included S. guianensis (SG) [60%], Pontoporia blainvillei (PB) [16%], Tursiops truncatus (TT) [12%], Steno bredanensis (SB) [4%], Stenella frontalis (SF) [4%] and Balaenoptera acutorostrata (BA) [4%]. Bycatch was suggested as causa mortis for 14 animals (9 SG, 4 PB, 1 SF). In lungs, pneumonia [44%], edema [16%], bronchopneumonia [16%], pleuropneumonia [8%], pleuritis [4%] and hemorrhage [4%] were observed. CNS findings included encephalitis [12%], meningoencephalitis [8%], spongiosis [4%], polioencephalomalacia [4%] and meningitis [4%]. Seven animals presented lesions suggestive of morbilliviruses. The IHC assay revealed immunolabeling in 11 CNS fragments (5 SG, 3 PB, 1 TT, 1 SF and 1 SB) and 8 lungs (6 SG, 1 TT and 1 SB), contrasting with previous studies where pneumotropism predominated in SG. This difference may be related to a higher neurovirulence strain. All the morbilliviruses transiently infect the CNS, but the development depends on the efficiency of the immune system response. This disease induces immunosuppression, survivals of sub-acute condition may progress to secondary infections. In conclusion, CeMV occurs on the Paraná coast, potentially facilitating the bycatch

Assessment of marine mammals bycatch rates in Chilean demersal fleets

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Bycatch of marine mammals by fishing fleets has become an issue of global concern, mainly due to drastic declines in population abundances of several species and increasing evidence of such interactions from monitoring programs. As a response, many RFMOs and countries have taken actions to afford this issue. Consequently, as of 2013 Chile incorporated permanent monitoring programs to register bycatch and discards during fishing operations through observers on board. Considering records and operational information obtained during 2017, this work evaluates marine mammals bycatch rates in different industrial fleets that operated in demersal Chilean fisheries. The study included: one crustacean trawling fleet (CRTF, 29°S–38°S), two hake trawling fleets (SHTF, 33°S-34°S; LHTF, 34°S-40°S), two multi-specific trawling fleets (FRTF and FATF, 41°S-57°S), and two long line fleets (PALF and SHLF, 46°S-57°S). The bycatch rate estimators used were based by cluster sampling design. The results showed that two species of sea lions, *Otaria byronia* and *Arctophoca australis*, were caught incidentally by the fleets studied. Both, the FRTF and FATF fleets did not exhibited marine mammals bycatch. Contrarily, higher rates were observed in the SHTF fleet (0,262 animals/haul) and, to a lesser extent, in the LHTF (0,127 animals/haul). Bycatch rates of 0,054 animals/haul were observed in FRTF and FATF, while, lower rates were observed in the CRTF fleet (0,004 animals/haul). Regarding to mortality of specimens caught, it varied between 34% and 90% depending on the fleet. The differences observed may be explained by the proximity of the operations to sea lions' colonies. Thus, higher rates were observed in fleets that operated closer to the coast and during winter season when animals search for food. These results provide evidence of the impact of each fleet on marine mammals bycatch, allowing focusing and customizing the mitigation efforts according to the scale and features of the problem.

Estimation of bias in distribution and abundance of different cetacean species using data collected during seismic surveys.

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Marine mammal data are often difficult and expensive to collect. Seismic surveys generate abundant data on marine mammals and may reach extensive offshore areas but is rarely used to assess species distributions and abundances due to the bias and uncertainty associated with the noise produced by the vessels. Cetaceans in the UK North Sea waters have been widely studied and seismic survey effort and sighting data systematically collected, thus constituting a perfect test area to account for the bias and assess the accuracy of the distribution and abundance of different cetacean species based on data collected in seismic surveys.

Data from 1467 seismic surveys between 1996 and 2018 were examined and compared to previous not biased works. To take into account detection bias and environmental conditions while specifically addressing the local-scale dependence structure of the data, we use a model-based inference approach, which assumes occurrences spatial locations as a point process using a spatial Log-Gaussian Cox process. The method adopts a flexible Stochastic Partial Differential Equation (SPDE) approach to model spatial structure in density and Integrated Nested Laplace Approximation (INLA) for Bayesian inference, simultaneously fitting detection and density models at fine scale.

Over 11,500 sightings and acoustic detections of cetacean species were identified, being white-beaked dolphins the most frequently encountered species, followed by Atlantic white-sided dolphins and minke whales. Sperm whales, harbour porpoises and long-finned pilot whales were also commonly found, while fin whales, killer whales and short-beaked common dolphins were moderately sighted.

Results are compared with previous abundance and habitat use studies in the area for the main species. Bias estimation opens the door to the use of this type of data to estimate the potential distribution and abundance of cetaceans in other regions where there is a lack of independent data but seismic surveys occur.

Conservation of the Amazonian Manatee Trichechus Inunguis (Sirenia: Trichechidae), in Loreto - Peru.

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The Amazonian manatee *Trichechus inunguis* is a purely aquatic herbivorous mammal hunted for its meat and marketed as pets, regularly trapped in blackwater lakes and streams in and near the Pacaya-Samiria National Reserve in northeastern Perú. These are also accidentally caught in fishing gear by fishermen who also use the meat as bait to catch some species of Amazonian fish. If we do not reduce human impact, these species may disappear.

Since 2007 the Amazonian manatee has been conserved, with the "Rescue, rehabilitation and release" program of this species, it has managed to rescue 51 manatees that were living in captivity and in deplorable conditions, 23 individuals (45.10%) were released in areas protected natural, being monitored for 8 to 10 months by a radio telemetry system, 17 individuals (33.33%) died in the rehabilitation process, most of these were found in a cachexic state; currently there are 11 individuals (21.57%) among offspring, juveniles and adults, 08 of them ready for the next releases. It was reported the birth of 02 manatees in captivity, guaranteeing the survival of this species for future populations.

An educational program is also developed, with the purpose of generating environmental awareness and positive emotions in children and adults regarding the conservation of this species in rural communities and cities in our region, using different methodologies, such as: talks, workshops, leisure activities, guided tours and especially contact with nature and thus guarantee future generations of young people who can protect our resources. In the last 3 years the hunting of this species has been reduced and an increase of the populations in the conservation areas is observed. It is advisable to encourage the monitoring of threats, and the establishment of abundance index and basic information for decision making, including local people for the conservation of this species.

Using photo-ID for assessing bottlenose dolphin skin lesions

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PhotoID studies have provided information about effects of natural and anthropogenic impact factors on different species of cetaceans. In this study we analysed photographs of the bottlenose dolphin *Tursiops truncatus* collected between the years 2012 and 2018 at El Hierro (Canary Islands, Spain) to identify signs of interactions or lesions on the skin of the dolphins. We found signs of viral, bacterial, mycotic and parasitic infections, neoplastic diseases, other non-infectious diseases, and intra/interspecific interactions, as well as human interactions. In addition, we found many cut dorsal fins, which could be due to on-going interactions of dolphins with deep water artisanal hook fisheries, or with debris. These results have implications for the conservation and management of this critical species in the Canary Islands and highlight the need to evaluate the interactions with fisheries and other human impacts within existing SACs designated in the archipelago to protect bottlenose dolphins.

Studies of Northern elephant seal (Mirounga angustirostris) population demographics and social structure at Piedras Blancas, California: A multi-faceted collaborative effort.

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Piedras Blancas (PB), California is home to the largest mainland northern elephant seal (*Mirounga angustirostris*; NES) rookery (breeding site) in the world. It comprises 6 miles of unconnected beaches housing around 25,000 NES. Cal Poly has initiated the first formal study of this population. Here we report the results of our pilot efforts, during the 2018 and 2019 breeding seasons. Our current objectives are to: (1) record NES movement between breeding sites, (2) collect baseline population demographic data, (3) analyze mating success of males in relation to beach geography, and (4) measure basic morphometric data for weanlings. We tracked NES movement using dye marks, flipper tags, and re-sights. Citizen scientists assisted with re-sights, expanding our efforts. Demographic data and mating success were investigated through visual male-female aggregation (harem) counts via weekly visual surveys. Weaning weights and morphometrics were collected from pups within 5 days of weaning. In each breeding season, we conducted 26 surveys, marked and/or tagged 425 NES, and measured 50 weanlings. Across seasons, we have obtained over 500 re-sights of individuals, including approximately 50 re-sights contributed by citizen scientists. Preliminary analyses of 2019 NES

weanling data suggest an 8% higher average weaning mass for males compared to female weanlings (P = 0.022), indicating an earlier manifestation of sexual dimorphism than observed at other rookeries. We have also documented differences in overall weaning weights between beaches within the rookery, suggesting lower weaning weights at beaches subject to greater human disturbance. The PB population of NES is growing exponentially and migrating to new beaches to meet their spatial needs. We are working with California State Parks, which manages the land, to ensure the data we collect informs the management plan for this rookery as the NES population continues to grow and human-seal interactions become more common.

Modeling behavioral responses of fin whale (Balaenoptera physalus) to whale-watching tourism in the Marine Reserve Isla Chañaral, northern Chile.

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Whale-watching (WW) has exponentially grown over the last few years, becoming not only an economic alternative for local communities, but also an important educational tool. However, several studies have shown that some cetaceans exhibit behavioral changes in response to WW boats, and thus there is concern that this activity may be detrimental to target species. In Chile, the Marine Reserve Isla Chañaral is an important place for whale-watching activities, due to a high diversity of cetaceans and the frequent occurrence of the fin whale (*Balaenoptera physalus*). During austral summers from 2014 to 2018 we analyzed short-term responses (travelling and resting behaviors) of fin whales to the WW tourism using the theodolite method. We modeled changes in the reorientation, linearity and speed as variable responses. The co-factors used were: tourism scenario (absence of boats, with boats and after boats), month, year, group size, number of boats and distance from land station. For resting behavior, the most significant co-factors for all the variable responses were month and tourism scenario, while for travelling month and year were the co-factors. At rest, the three variable responses changed during the post-boat scenario, with an increment in speed and linearity and a decrease in reorientation, which suggests that fin whales move from rest to travel. Also, for resting behavior, the speed increased during February, the month where WW intensifies. Similar results were observed in this month for travelling behavior, with an increment in speed. It is important to note that the speed of whales decreased during 2017-2018 years, which could be associated to an improvement in approaching techniques of tour operators after participating in a sustainable tourism workshop. Even when our results indicate that fin whales are being impacted by WW, an appropriate behavior of tour-operators seem to diminish impact the short-term responses by fin whales.

Assessing dolphin extinction risk in presence of hybridization

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Hybridization has been documented in several marine mammal species. Human disturbance can increase hybridization rates by affecting species distribution and abundance. Depleted species, in particular, may face genomic extinction due to lack of conspecific mates and high introgression rates. Understanding how introgressive hybridization can lead to genomic extinction helps identify the management action needed to protect threatened species and populations. However, data on hybridization rates and fitness parameters (i.e., fertility and survival) of parental and admixed individuals are often missing. In such cases demographic models can be used to: 1) project population dynamics under possible hybrid and parental fitness hypotheses (i.e., hybrid vigour, outbreeding depression) and 2) identify the main demographic parameters affecting population extinction. Here, we present a new matrix population model to project hybridization dynamics, and we use it to evaluate the hybridization outcomes for two odontocete

populations interbreeding in the semi-enclosed Gulf of Corinth, Greece: the common dolphin *Delphinus delphis* and the 60-fold more abundant striped dolphin *Stenella coeruleoalba*. We projected hybridization dynamics for 100 years under different fitness scenarios for parental and admixed individuals. We performed a sensitivity analysis to identify the main demographic parameters affecting the probability of genomic extinction of the two populations. Common dolphins were predicted to go extinct in one generation time (16 years), regardless of the scenario. The growth rate of striped dolphins was affected by hybridization, and their population could eventually reach genomic extinction—except for scenarios where the fitness of admixed individuals was lower than that of parentals. The probability of extinction of both striped and common dolphins was most affected by the survival of mature and juvenile individuals. For common dolphins, the low initial abundance was also important. Our study shows that hybridization represents an additional and important threat that may contribute to the eradication of local populations.

Rorqual ingestion estimates based on direct measures of feeding rates and prey quality.

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As ecosystem engineers, rorqual whales have oversized impacts on marine food webs by ingesting vast quantities of low-trophic level prey while also aiding in nutrient cycling. However, evaluating the biomass of prey consumed by rorqual whales is challenging in large part because prey densities are difficult to quantify, lunge-feeding rates have been intractable to measure, and measuring both concurrently is extremely challenging. The majority of published estimates on rorqual prey consumption have been calculated via extrapolations of metabolic rate rather than by measuring foraging rates and prey concentrations directly. Using high-resolution biologging technology (95 deployments on humpback, fin, blue, and Antarctic minke whales), drone photogrammetry, and active acoustic prey mapping, we report estimates of prey consumption in four lunge-feeding rorqual species. Our results indicate prior estimates of maximum daily and annual consumption are likely underestimated by a factor of five. The implications of our findings are wide-ranging. This includes re-evaluations of the net primary productivity and krill biomass required to sustain historical and current populations of rorqual whales globally, the amount of nutrient recycling and redistribution (e.g. Fe, N, P) due to fecal deposition, and food-web interactions with other krill predators. We conclude that although the magnitude of these impacts on the ecosystem provided by rorqual whales have been dramatically reduced due to industrial whaling, these estimates increase their considerable ecological role particularly as their populations continue to recover.

The cave use of Mediterranean monk seal (Monachus monachus) in the Gökova special environmental protection area between 2016 and 2018

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This study was conducted between 2016 and 2018 in the Gökova Special Environmental Protection Area. The purpose of the study was to identify monk seal caves and classify them according to frequency of use, and to estimate the local monk seal population in the area to identify primary monk seal habitats as core zones.

First, the local fishers and sailors were interviewed for the location identification of the seal caves. Afterwards, these caves were checked by skin diving whether they are suitable for monk seal use,

and the camera-trap installations. Six camera-traps in four caves were mounted for monitoring. The camera trap settings were adjusted motion trigered in hybrid-mode taking both video images (10 - 20 sec) and three photos. After photo shootage 3 to 7 min-pause was also set. The recordings (N= 6,778 events comprising both three photos and a video footage) from all caves were analysed to determine the use (resting and/or breeding) and its frequency, seasonal and circadian cave usage, and identified individuals' gender and the age group.

Three of the caves mounted with cameras were identified as possible breeding and/or nursery grounds, confirmed by the presence of monk seal juveniles inside. It is found out that the cave usage increases in Spring. Besides, the existence of juveniles in early winter proved breeding. The data were compared with Pearson's Chi-squared test, and it is found out that there were significant differences among the caves according to their location and use of day-periods. Monk seals were mainly using the caves nocturnally, and revealing a diurnal activity pattern. During the study, four adult females and two juveniles were identified. The main observations of mother-juveniles highlight the important breeding/nursery grounds where core protection areas to be considered. This study was funded by the Zoological Society of London The EDGE of Existence Programme.

Mother-offspring and sibling whistle comparisons in bottlenose dolphins

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The factors governing signature whistle development in bottlenose dolphins are still largely unknown, even after decades of research. A 1995 study of 42 long-term resident mother-calf pairs recorded in Sarasota Bay, Florida, found that males were significantly more likely to produce whistles similar to those of their mothers than were females, and that females were more likely than males to produce whistles highly distinct from those of their mothers. We sought to investigate whether this pattern upheld with a much larger sample size. Similarity of whistles from 158 mother-calf pairs (80 male, 78 female) was quantified on a scale of 1 to 5 by multiple judges. Unlike the 1995 study, we did not find a significant difference between males and females; 29 males and 26 females, comprising 35% of all calves, produced whistles highly similar to those of their mothers (values greater than 3.7). We looked more closely at patterns of similarity among the 40 mothers in our sample that had two or more calves (mean = 3, total 122 calves), and found four patterns of mother-calf whistle similarity (numbers in parentheses refer to mothers): all calves different (17), all calves similar (4), more than 1/2 similar (3), 1/2 or fewer similar (16). In several cases, we noticed striking similarities among whistles of siblings. Half of the mothers (20) had at least two calves with whistles similar to each other, and all of the calves (17) of six mothers produced whistles similar to their siblings. Yet in only three of these six cases did the calves also produce whistles similar to the mother. Thus, siblings appear to play a role in signature whistle development. Gaining a better understanding of the process of signature whistle development will provide insight into how signature whistles function in the natural communication system of dolphins.

Acoustic harassment devices (seal scarers) can affect harbour porpoise hearing temporarily

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Acoustic harassment devices (AHD) are regularly used to deter marine mammals, e.g. prior to pile-driving activities in German waters to deter harbour porpoises from the vicinity of the construction site. While AHD are applied to prevent a TTS from pile driving noise, these acoustic signals itself have the potential to induce a TTS. This study investigated the potential of artificial seal scarer signals to induce a TTS in harbour porpoises, by experiments with an animal in human care, funded by the Federal Agency for Nature Conservation (BfN). Baseline hearing thresholds were determined at 20 and 28 kHz, by measuring auditory evoked

potentials. The animal was exposed to an artificial seal scarer signal, consisting of a 0.5 s sine tone at 14 kHz and four overtones with decreasing amplitudes at 28, 42, 56 and 70 kHz. Hearing thresholds were determined prior and post exposure to evaluate effects of exposure on hearing. One sound exposure was conducted per day, starting at a low sound energy level which was gradually increased day by day. We found significant temporary hearing shifts at both tested frequencies. The TTS onset, defined as a hearing shift significant from baseline hearing, was determined at 142 dB re 1 µPa²s at 20 kHz and at 137 dB at 28 kHz. We provide evidence, that single pulses of seal scarers, which are currently applied, have the potential to induce a TTS, leading to potential hazard zones between 50 (deep water) and 1000m (shallow water), depending on sound propagation. Effects of multiple exposures are difficult to predict, due to the randomized intervals between signals between 0.6 and 90 s. In order to prevent a TTS by seal scarers, we suggest slowly increasing source levels, allowing the harbour porpoise to flee.

Spatio-temporal patterns in humpback whale acoustic behavior in the Southern Ocean

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Evidence for off-season humpback whale (*Megaptera novaeangliae*) acoustic presence in high latitude feeding areas is accumulating for Northern Hemisphere waters. By contrast, to date, long-term studies investigating humpback whale vocal behavior in the Southern Ocean are limited to the coastal region. This study uses multi-year data from the HAFOS (Hybrid Antarctic Float Observing System) recording network in the Weddell Sea to investigate spatio-temporal patterns in humpback whale vocal behavior. Between 2010 and 2017, passive acoustic data were collected along the Greenwich meridian, in the central Weddell Sea and off Elephant Island. Humpback whale calls were automatically detected and manually verified to obtain hourly presence information. Humpback whales were acoustically present primarily during austral summer and autumn (March, April, May, June and July). Acoustic presence was most pronounced (>60% of recording days per month containing calls) when sea ice concentration was close to zero. Furthermore, humpback whale song was present at various recording sites in April, May, June and July. The length of the period during which songs were present, as well as the number of song hours per day, increased with decreasing latitudes of the recording sites. At least seven distinct phrase types are identifiable across all recording sites. This study demonstrates that substantial humpback whale presence in the Southern Ocean is not limited to the coast, but extends to pelagic regions. The presence of social sounds and song during extended periods suggests that whales were not just transiting the area, but occupied the area for some time, possibly exploiting local food patches. Additionally, the presence of song on the Antarctic feeding ground indicates that some individuals mix feeding or migratory movement with reproductive behavior. In an ongoing project, further analyses will provide additional insights into the acoustic behavior and population identity of humpback whales on the Antarctic feeding grounds.

Visual and passive acoustic monitoring of the diel activity of wild harbour porpoises (Phocoena phocoena) in Fyns Hoved, Denmark

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The harbour porpoise *Phocoena phocoena* is the only resident cetacean species in the Baltic Sea. Since it has been classified as "Critically Endangered" in the Baltic Sea in 1996, protection of this species is immediately necessary. In this study, the activity pattern of the harbour porpoise in the coastal waters of Fyns Hoved, Denmark was investigated acoustically using passive acoustic monitoring devices (C-PODs) as well as visually with a tachymeter. 10 C-PODs were deployed continuously from 30th July to 2nd September 2018 in Fyns Hoved. The visual observation was conducted during daytime from a cliff in the study area. The results demonstrate that the detections of porpoises were significantly higher at the deeper C-POD stations than at the shallow stations during the evening. We found that significantly more harbour porpoises were detected during night than during the rest of the day. The comparison of visual and acoustic porpoise detections has shown that more porpoises were detected visually than acoustically. The results have extended the current knowledge

about the diel activity pattern of harbour porpoises in three ways: 1) This is the first study which indicates that the occurrence of harbour porpoises varied on even a very small space. 2) We assume that the harbour porpoise may be hunting during the day mainly with the special feeding behavior "bottom-grubbing". We conclude that the harbour porpoise could not be detected by the C-PODs during this behavior. These findings should be taken into consideration when planning further monitoring studies. 3) Because of the result that more porpoises were detected visually than acoustically, we recommend to compensate this potential limitation of the C-PODs during the day with visual monitoring to secure precise data collection. However, we suggest to conduct more research on this topic before a general conclusion can be made.

The effect of multi-target protocol on cetacean detection and abundance estimation in aerial surveys.

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A double-platform protocol was implemented in the Bay of Biscay and English Channel during SCANS-III survey (2016). Two observation platforms using different protocols were operating on-board a single aircraft: the reference platform ("Scans"; the same protocol as implemented during all SCANS surveys), targeting cetaceans, and the "Megafauna" platform, recording all the marine fauna visible at the sea surface (jellyfishes to seabirds; as implemented during SAMM, REMMOA, ObSERVE and ASI surveys). We tested for a potential bias in small cetacean detection and density estimation when recording all marine fauna. At a small temporal scale (30 seconds), our results provided overall similar perception probabilities for both platforms. Small cetacean perception was higher following the detection of another cetacean within previous 30 seconds in both platforms, but decreased following the recording of any seabirds in the Megafauna platform only. However, at a larger scale (>10 km), this small-scale perception bias had no effect on the density estimation, since the two protocol provided similar small cetacean density estimation. As a result, there was no evidence of lower performance regarding small cetacean population monitoring for the multi-target protocol in our study area. As it was characterised by moderate densities and small spatial overlap of cetaceans and seabirds, any extrapolation requires caution. Nonetheless, by permitting the collection of cost-effective quantitative data for marine fauna, anthropogenic activities and marine litter at the sea surface, the multi-target protocol is a valuable option of scientific survey optimisation to achieve efficient biodiversity monitoring.

World Heritage Site "Wadden Sea" – a challenging habitat for cetacean conservation and management.

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The Wadden Sea is an area in the southern North Sea consisting of a complex landscape including islands, mud flats, tidal channels, estuaries, rivers and a highly convoluted coastline. In 2014 national parks and EU - Special Areas of Conservation in Danish, German and Dutch waters were combined under the umbrella of the World Heritage Site (WHS) "Wadden Sea".
In the last decades the distribution of the North Sea harbour porpoise has changed notably by shifting south. Numbers in coastal areas, in particular the southern German Bight and along the Dutch coast, have increased substantially, with indications that this increase extends into the Wadden Sea as well as estuaries and rivers.

To provide a first insight on the conservation status of harbour porpoises in the WHS we compiled available information from aerial surveys, satellite telemetry, acoustic monitoring, incidental sightings, drivers for prey availability as well as the potential impact of predation by grey seals. This unique habitat with strong tides, narrow channels and turbid waters poses a challenge to porpoises that need to navigate and find food. New studies

with tagged porpoises provide evidence that some animals have specialized to live in this habitat year round. Passive acoustic studies indicate that others may seasonally follow migrating fish up rivers or adapt their feeding activity to tidal patterns.

The WHS is not only a highly complex habitat, it also has a highly diverse management set-up. The patchwork of regional stakeholders with different interests co-existed in this area long before the WHS designation. We highlight how the mandate of the WHS relates to those defined under EU and national laws/agreements to identify mismatches. Our aim is to clarify what role of the WHS can play to find a way forward to determine the conservation status of the harbour porpoise in the WHS.

Accounting for positional uncertainty when modeling received levels for tagged cetaceans exposed to sonar

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Exposure to anthropogenic sound can have various negative behavioral and physical effects on marine mammals and is of increasing ecological and regulatory concern. In particular, the response of cryptic deep-diving beaked whales to military sonar is a pressing and complex issue. To make inference on the response of individual whales to noise, it is critical to know what received levels (RLs) the animal actually experienced. Most behavioral response studies to date have used relatively short-term, high-resolution acoustic tags that provide direct RL measurements. Because of their short duration these tags do not allow for assessments of longer duration behavior, both before and after a disturbance, that may tell us more about the nature of response. In contrast, most longer-duration tags lack high-resolution kinematic data and the ability to directly measure RL. Here we address these issues and efforts to derive robust statistical characterizations of RLs using animal movement and sound propagation modeling for longer-duration tags in the context of a behavioral response study off Cape Hatteras, NC, USA. In the autumn of 2017, we tagged 9 Cuvier's beaked whales and 3 short-finned pilot whales and conducted controlled exposure experiments using simulated and operational military mid-frequency active sonar. We used sound propagation modeling methods and modeled positions of individual animals to estimate RLs and statistically describe uncertainty. When properly accounting for positional error, single median RL estimates drastically underestimate the full range of plausible values, with ranges in estimated RL variance for beaked whales often exceeding 40 dB. Additionally, ancillary data from focal follow research can significantly narrow estimated RL ranges. Results suggest that though satellite tags record data over longer timeframes, the deep-diving behavior of beaked whales means that estimates of received level can vary broadly. Accounting for this uncertainty using robust statistical modeling is critical when assessing exposure-response relationships.

Population structure characterised by high within-area relatedness in North Atlantic and Mediterranean Sea fin whales (Balaenoptera physalus)

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Detecting weak population structure based on estimates of allele/haplotype frequency divergence alone depends on the degree of divergence, statistical power and genetic markers, but holds low power at "ecological" dispersal rates. Kinship-based methods, on the other hand, are better suited at "ecological" rates and complementing traditional population genetic approaches. We combined conventional *F*-statistics and coalescence methods with kinship-based approaches to assess the population structure of the North Atlantic (NA) and Mediterranean Sea (MED) fin whales (*Balaenoptera physalus*). An analysis based upon 20 microsatellite loci and 450 base pair mitochondrial DNA control region sequences from ~1,600 individuals identified a break in gene flow between the NA and MED (F_{ST} = 0.005, $P < 0.001$ and F_{ST} = 0.17, $P < 0.001$ for nuclear and mitochondrial markers, respectively), connected by asymmetric gene flow. Among NA sampling areas, a low degree of isolation-by-distance was detected between the western and eastern NA at both nuclear ($r = 0.30$, $P = 0.018$) and mitochondrial ($r = 0.32$, $P = 0.016$) markers. Average pairwise relatedness among individuals was higher within compared to between regions ($t = -10.62$, d.f. = 911.83, $P < 0.001$). We identified 140 parent-offspring dyads among which were 125 dyads with both individuals sampled in the same area and 15 dyads where members were sampled in different areas, ranging up to 3,300 km apart. In the western NA, evidence of weak, fine-scale structuring was detected between the Gulf of Maine and Gulf of St. Lawrence. The high within-area relatedness coupled with substantial connectivity among areas suggests that fin whale migratory behaviour differs from species with well-characterised seasonal migratory patterns, such as humpback whales (*Megaptera novaeangliae*). While fin whales have the capacity of wide-ranging movements, the low heterogeneity among areas was consistent with maternally-directed site-fidelity and short-range seasonal movements.

Variation in ringed seal (Pusa hispida) bone mineral density from 1897-2018.

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Various factors, such as contaminants, might affect process of bone structuring and can lead to an imbalance causing systemic or local bone mass. In the Baltic Sea, pollution with DDT and PCBs have been claimed to influence bone structure and composition as well as reproductive success leading to a decrease in the local ringed seals populations in the 1970's.

The aim of the present study was to analyse temporal changes in bone mineral density

(BMD) over time in Baltic ringed seals using samples of the Swedish Museum of Natural History. 106 skulls were used for bone investigations and were divided into three periods according to the collection year: between 1897 and 1905, between 1973 and 1985 and after 1985 up to 2018. All skulls were examined by dual-energy x-ray absorptiometry and the obtained results on BMD were correlated with the historical PCB and DDT presence with the potential risk of influencing bones constitution. It seems that males had a higher BMD than females (linear model: *p*-value=0.0579, F-value=32.07). Bone mineral density fluctuated between the three study periods (linear model: *p*-value=6.98e-09, F-value=39.87) with the lowest BMD content found between 1897 and 1905. An ANCOVA to test BMD versus period and skull length revealed a decreasing, non-significant trend (*p*-value=0.0738, t-value=-1.855, F-value=2.908) with respect to the relationship between length and the second period. Moreover, this study links these findings with the contaminant values of PCB and DDT for the respective years. The highest peak was observed in the Gulf of Bothnia in the second period.

In conclusion, the variations between 1897 and 2018 may to a certain extent reflect normal fluctuations; however, an effect of PCBs and DDTs cannot be excluded. It was explored if the contaminant burden may explain the difference between early years showing low BMD and late years showing higher.

Sound propagation changes formant-like spectral peaks in humpback whale song.

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The aim of this study was to assess the viability of acoustic communication of size-related cues (specifically, formants) by baleen whales. Songs often travel many kilometers before reaching potential recipients and are therefore susceptible to propagation degradation. Spectral cues are susceptible to modification during transmission as reflections from the surface and bottom result in frequency-dependent constructive and destructive interference, possibly masking information cues typically found in terrestrial mammal vocalizations. Playback studies were conducted off the west coast of Puerto Rico using synthetic sounds, without formants, and humpback whale song units, with formants. Sounds were recorded at various distances (up to 1500 m) from the source, and the spectral content at varying distances was compared. Formant-like peaks and notches were found in the recordings of synthetic sounds, which were not present in the source recording. Spectral envelopes of the same sounds of both types also differed between recording distances. In addition, a recording was made of a singing whale over approximately 40 minutes as the boat drifted at different angles from the whale and a steep underwater slope. Spectrograms of the same phrase type at different points in the recording also showed shifts in formant peaks. The addition and modification of formant-like peaks indicate that size-related cues are not reliable transmitted over long distances. If baleen whales do produce reliable, formant-based size cues in their vocalizations, then these cues may only be reliable at short distances, such as within feeding, social, or competitive groups.

An alternative to captive cetacean displays in the Mediterranean: The Aegean Marine Life Sanctuary.

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The future of captive cetaceans comes into question as the popularity for their use for entertainment purposes declines. More travel companies are no longer offering visitation to facilities holding captive cetaceans; new technology is effectively replacing the educational function of dolphin displays and research innovations are taking place on-site via non invasive studies on free living animals. Therefore, captive cetaceans should be rehomed and their welfare should be the priority when keeping them for a lifetime.

The Aegean Marine Life Sanctuary will provide home to dolphins at a natural environment, providing them expert veterinary care at a research and educational facility at the Greek bay of Lipsi.

After a comprehensive analysis of different potential sites, the setting at Vroulia Bay fulfills all necessary environmental and social criteria: the geomorphic and oceanographic characteristics, high biodiversity and water quality, overwhelming

local support at a remote but easily accessible island in the northern Dodecanese.

So far, negotiations for land agreement, mapping the extent and assessing the health of seagrass meadows, analysis of species biodiversity and water quality and preparation of the veterinary clinic have been the main actions of the team along with the numerous protocols prepared and the licensing process.

Using renewable energy sources, under an strict non-breeding policy will make sure no new cetaceans are required to remain at the sanctuary, and an invitation-only policy for visitors will ensure the minimal disturbance to the animals.

The project is an innovative endeavour based on a scalable and cost-efficient model that can be easily replicated.

Quantifying and characterizing acoustic activity patterns of Indo-Pacific humpback dolphins (Sousa chinensis) in Hong Kong's waters using Passive Acoustic Monitoring.

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Understanding the behavioural ecology of cetaceans in environments with high human pressure can increase our effectiveness in minimizing the conflicts between the needs of cetaceans and humans. Indo-Pacific humpback dolphins (*Sousa chinensis*) of Hong Kong's waters are threatened by many human activities and declining in number as a result. Cetacean Porpoise Detectors (CPODs) offer a non-invasive method to study these dolphins and reduce several limitations of visual observations and thus, can provide valuable information on the occurrence, daily activity and habitat use of the dolphins. As part of a passive acoustic monitoring study to understand the occurrence of the dolphins within two marine protected parks in Hong Kong (Sha Chau and Lung Kwu Chau Marine Park - SCLKCMP and the Brothers Marine Park - BMP), three CPODs were deployed within each of the marine parks between June 2017-18. A diel pattern in acoustic activity was found with significantly more detection positive minutes (DPMs) per hour recorded at night than during the day. Acoustic activity also varied throughout the year with the highest number of DPMs in November to January in SCLKCMP compared to the highest numbers from January to March in BMP. Lastly, DPMs also varied greatly among the six CPOD sites with the highest DPMs observed at the central site within SCLKCMP and lowest at the northwest site within BMP which is closest to a major development project. In addition, the mean DPMs per day was higher at the SCLKCMP sites (combined) than at the BMP sites (combined). The results of this passive acoustic monitoring study compliment information obtained through visual surveys and together provide a better understanding of dolphin activity patterns within the two marine protected parks, which can help to improve the conservation of humpback dolphins in Hong Kong's waters.

Cuvier's beaked whales in high fidelity: Medium-term archival tags allow for detailed behavioral studies.

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Previous studies of the behavioral response of Cuvier's beaked whales (*Ziphius cavirostris*) to Navy sonar have relied on a dichotomy of either high-resolution short-duration tags, or low-resolution long-duration tags. We utilized new multi-sensor, high-resolution dart-attached archival tags to collect behavioral data from Cuvier's beaked whales exposed to operational naval sonar at a training area in Southern California, bridging the gap between earlier techniques. Tag sensors included a Fastloc GPS with depth, temperature, and a 3-axis accelerometer sampling at 16 Hz, and in some deployments a hydrophone (96 kHz) and additional 3-axis magnetometer and accelerometer sampling at 50 Hz. Tags remained attached for up to 19.2 days, and FastLoc GPS locations were often obtained at every surface series, allowing the first robust assessment of horizontal displacement during exposure. Tagged animals were exposed to ship or helicopter sonar 23 times during deployments, at distances as close as 8 km. Apparent responses varied with sonar type,

distance, and behavioral state, and included a 30-min surface bout during which the whale displaced at > 10 km/hr, and a 163-min dive reaching 1,657 m, during which the whale moved > 7 km horizontally. The high-resolution accelerometry data allow for detailed analysis of fluking, jerk, and ascent/descent rates which can provide new insights into the energetics and dive physiology of this species as they pertain to both stranding risk and long-term fitness. With attachment durations lasting multiple days to weeks, this new tag technology provides a way to assess responses to anthropogenic impacts by collecting adequate baseline data at high fidelity to account for individual variability in diving behavior.

Comparison of eye dimensions in toothed whales

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The eyes of cetaceans and other marine mammals are well adapted to life underwater by a thick sclera protecting the eye from high pressure or temperature related damages and the almost spherical lens compensating the low refraction power of the cornea. However, there are few detailed data about the composition and sizes of cetacean eyes. In this study, eyes of five different cetacean species were imaged by CT and MRI. 3D models of the eyes were reconstructed and the volumes of the sclera, the vitreous body and the lens were measured in relation to the size of the skull. The Amazon river dolphin (*Inia geoffrensis*) had the smallest eyes among the species studied here (864mm³). The closely related Franciscana dolphin (*Pontoporia blainvillei*) had similar eye volume (985mm³). The harbor porpoise (*Phocoena phocoena*) had more than 7 times voluminous eyes (7,323mm³) than the first two species. Bottlenose dolphins (*Tursiops truncatus*) had an eye volume of 12,714mm³. Interestingly, the late-fetal Sowerby's beaked whale (*Mesoplodon bidens*) had the biggest eyes (33,773mm³) These results reveal that the eyes of the so-called river dolphins (*I. geoffrensis, P. blainvillei*) are far smaller than the eye of the harbor porpoise despite their similar body length. This fact is also reflected by the data of eye axis length in relation to skull width (*I. geoffrensis* 11%, *P. blainvillei* 12%, *P. phocoena* 19%). The functional background, however, of this fact is not clear.

How strong is the link between the distribution of sand eels and harbour porpoises in the north-eastern German Bight?

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The seasonal abundance and distribution of harbour porpoise (*Phocoena phocoena*) in the German North Sea shows a strong variation. However, on a more local scale the seasonal occurrence may follow a constant pattern in consecutive years. We conducted digital aerial surveys covering all seasons over several years to obtain abundance and distribution of harbour porpoise in a ca. 3300 km² study area in the north-eastern German Bight. In parallel, we collected continues data on porpoise acoustic activity with C-PODs at 12 different positions inside the study area. Based on ICES fish bottom trawl survey data we inferred sand eel distribution within the survey area. By comparing harbour porpoise distribution to sand eel distribution a close connection during spring and summer could be proven.

Effects of whale watch tourism on humpback whale (Megaptera novaeangliae) behavior and understanding passenger attitudes toward regulations in Juneau, AK.

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The North Pacific humpback whale's feeding grounds in Juneau, Alaska have rapidly developed into a popular whale watch destination during the summer months (May-September). The Juneau whale watch industry has tripled in size in the last 18 years, currently numbering over 65 vessels. Viewing guidelines/regulations established in 2001 are outdated and may no longer be effective to manage the industry. The aim of this study is to provide a holistic understanding of whale watch tourism in Juneau by assessing 1) humpback whale movement and behavioral responses to vessel presence and to the number of vessels present and

2) passenger attitudes and knowledge regarding whale watching guidelines/regulations. Data were obtained during summer 2016-2017, comprising shore-based tracking and observations of 201 humpback whales and surveys completed by 2331 passengers. Linear mixed effects models indicated that whales in the presence (vs. absence) of vessels exhibited a 40% higher deviation in linear movement ($p = 0.001$), a 6% increase in swimming speed ($p = 0.047$) and a 7% decrease in inter-breath intervals (IBI) ($p = 0.025$). For each additional vessel present, deviation in linear movement increased by 6% ($p = 0.022$) and IBI decreased by 4% ($p = 0.001$). Compared to before a whale-watching tour, passenger awareness of whale watching guidelines/regulations doubled and strong support for guidelines/regulations increased immediately following a whale-watching tour and six-months after the tour (all $p < 0.010$). It is recommended that management revisit the current measures in place to better suit the industry today and that passenger education during whale watching tours be included as a potential management tool to encourage operator compliance. As vessel presence increases in this region, adherence to updated whale watching guidelines/regulations is likely to become increasingly important to mitigate the cumulative effects of short-term changes to whale behavior.

Veterinary Expert System for Outcome Prediction (VESOP): A Bayesian model to predict changes in cetacean population vital rates from measures of individual health.

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Understanding the connections among stressor exposures, health, and population vital rates is important for effective management, yet developing quantitative models of these connections is challenging. To address this need, we collated data from bottlenose dolphin (*Tursiops truncatus*) health assessment studies conducted at 8 sites along the southeast U.S. coast over a range of stressor conditions. We sought two types of data: 1) health measures from hands-on veterinary assessments, and 2) sighting histories from longitudinal photo-identification studies on the same populations. We compiled 839 dolphin health records, which include stress and reproductive hormones; hematology; serum chemistry; immune indices; pulmonary score; and body condition. We then developed the Veterinary Expert System for Outcome Prediction (VESOP), which uses the collection of health measures organized into expert rule-based panels to estimate probability of 2-year-ahead survival and successful reproductive outcome for pregnant females. VESOP is implemented as a logit model in a Bayesian framework and simultaneously fits conditional distributions from which missing health parameters can be drawn, allowing use of health records even if one or more values are missing. VESOP was trained using actual outcomes when observed (i.e., carcass retrieved or animal sighted alive after 2 years). Additionally, to aid in training VESOP we developed capture-mark-recapture models for the various populations, which independently estimated individual survival probabilities for dolphins whose survival outcome was not observed. VESOP analyses found that measures of chronic disease are the best predictors for 2-year survival. Dolphins with diagnoses of inflammation or anemia had a 4-fold (95% CI = 2.11-19.66) and 7-fold (95% CI = 1.48-10.66) increased risk of mortality, respectively, and those with both conditions had only a 50% chance of surviving 2 years. We combined the relative risks with prevalence estimates of the various conditions for each population to examine differences in predicted vital rates across the sites.

The deep, the shallow and the indecisive: Foraging strategies of Galápagos sea lions.

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Hunting in the tropical waters off the coast of Ecuador, Galápagos sea lions are confronted with strong, irregular fluctuations in prey abundance due to El Niño and La Niña events. Despite living in dynamic environments, marine predators frequently exhibit different, stable individual foraging strategies. Different foraging strategies are especially closely connected to the survival of an individual or its offspring, with large effects on population dynamics. Hence we studied individual differences in foraging behavior of Galápagos sea lion mothers during the 2018 El Niño conditions. The study colony, located on an islet in the center of the archipelago, has been part of a long-term study, providing life history data for the focal animals since 2003. Eighteen adult females, nursing a pup or one-year-old, were equipped for two weeks with biologgers collecting dive depth, location, and acceleration data. Exploring the dive data, we run a Principal Component Analysis followed by a Hierarchical Cluster Analysis, identifying four different foraging strategies. To get a better understanding of those strategies, dive depth and volume of 3D utilization distribution was analyzed, as well as the state-dependent distributions, calculated with hidden Markov models. To study the mechanisms and consequences of those strategies, we (1) used the long-term dataset to investigate the influence of those strategies on the mothers' body conditions and on the weight gain of their pups, two important components of individual fitness; and (2) compared the individual diving behavior to the space-use and behavior in the colony, obtained through resight rounds, focal animal observations and behavioral response tests. Studying the different diving strategies of this decreasing population of pinnipeds, and their consequences, not only gives an insight into how these animals handle current and future challenges, but also contributes to gain a better understanding of how these strategies develop.

How to get mutual benefit for whale watching companies and cetaceans

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Educational outreach can be achieved through responsible Whale Watching (WW). Here, we investigate the factors affecting customers' satisfaction on WW experience in the Strait of Gibraltar Important Marine Mammal Area. Between July and September 2017 and 2018, guides of the WW company TURMARES Tarifa submitted 398 questionnaires to customers randomly selected during the final part of each trip. Collected data included a general evaluation of the WW experience (a binary satisfaction index), an evaluation of the WW company (a mark from 1 to 10) and details on the profile of the customers, their evaluation of the educational activities associated to the experience, the perceived compliance with current legislation for WW activities, and the customers' change of awareness. Sighting and trip details were associated to the customers' answers to identify the factors affecting their opinion on the WW experience and on the company. 96.48% of customers expressed a general positive evaluation of the WW experience and most customers positively evaluated the WW company (mean ± SD = 8.6 ± 1.1). Results from multiple linear regression analysis and generalized linear models indicate that customer satisfaction and their evaluation of the WW company are not related to customer profile and trip details. Conversely, they are correlated to the overall quality of the WW experience and they significantly increase when customers are fulfilled with the information received during the trip and with some aspects related to the animal welfare, such as a slow approach to cetaceans. Customers asserting their awareness about cetaceans increased after the trip also better judged the WW company. In conclusion, improving education outreach and communication, and a respectful attitude during sightings, could produce higher customers satisfaction rates changing their level of awareness, with mutual benefits for the WW company, cetaceans and related potential conservation issues.

Acoustic analysis as a methodology for assessing stress in belugas (Delphinapterus leucas)

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Marine mammals are routinely exposed to a plethora of acute and chronic stressors, both natural

and anthropogenic. Effects of these stressors range from short-term changes in behaviour to long-term changes in reproductive fitness, foraging effectiveness, and spatial habitat usage. Concentrations of cortisol, a stress hormone, are used as a quantifiable measure of stress in free-ranging animals. Traditionally, cortisol levels are analysed from blood serum or plasma. However, sample collection is invasive, and confounding effects from the stress of research handling may make it challenging to get accurate baseline cortisol measurements using this technique. Acoustic behaviour could provide an alternative matrix for measuring stress non-invasively and at a fine time scale. In this study, acoustic and hormonal data collected during health assessments conducted on the Bristol Bay beluga population were used to evaluate belugas' vocal behaviour as it relates to the stressor of live capture. Acoustic recordings made during each animal's assessment (n=19) were analysed, and trends in vocal behaviour were related to serum cortisol concentrations measured at the beginning and end of each assessment. Acoustic and movement data collected remotely using DTAGs were used to relate vocal behaviour to the expected decrease in stress after release for eight of the 19 animals. Metrics measured by the DTAG's accelerometer and magnetometer, such as swim speed and circular variance in heading, were calculated to assess changes in the tagged whales' behavioural patterns. Characteristics and acoustic parameters of calls made throughout the tag deployment were compared to those made during the health assessment process. This allowed for fine-scale analysis of how vocal behaviour differed across stress contexts. Preliminary evaluation of acoustic recordings suggests that the assessment process had a silencing effect on beluga calling behaviour. Few phonations were recorded during assessments and in DTAG recordings made immediately following release.

Baseline soundscape analysis of a humpback whale breeding ground before port construction in the Gulf of Tribugá.

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Humpback whales annually migrate to Colombian waters to mate and give birth. The acoustic communication system of the humpback whale relies on an individual's ability to establish and maintain contact with conspecifics across vast and proximate distances. Current levels of tourism and artisanal fishing activities that support the livelihood of local communities in the Gulf of Tribugá (Colombia) are low, but a significant increase in industrial and commercial maritime traffic could mask critical communication space for whales to find, mate with, and protect one another. Considering the current government's interest in building a port in the area, a passive acoustic monitoring device (Ecological Acoustic Recorder (EAR)) was deployed in the Gulf of Tribugá between September and November 2018. Acoustic data were processed using an in-house Matlab GUI. Power spectral densities (PSDs) were computed in dB re 1 µPa2/Hz and estimated to 3-Hz resolution each minute, by averaging FFT snapshots (overlapped 50%) over one minute intervals. Results show that dominant sound contributors are humpback whale song, boat traffic, snapping shrimp, and fish, with some contributions from delphinid species and unidentified distant sound sources. Observations of spectrograms indicate that humpback whale songs stop during boat passes with enough acoustic energy to mask the song units. Three-dimensional propagation modeling maps have been generated to illustrate the ranges over which humpback whale song and boat engine noise could spread through all directions in the water column. These baseline levels of sound sources, the observed acoustic behavioral responses to noise, and maps of masking potential in the area will be discussed as the first part of a Before-After Control-Impact (BACI) marine study.

Immune-mediated hookworm clearance and survival of an otariid decrease with warmer ocean temperatures

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In the northern and southern Pacific Ocean, increases in ocean temperature are associated with a decline in marine productivity and fish stocks. These changes alter the foraging regimes and maternal attendance patterns of otariids, causing starvation and mortality among pups when changes in temperature are extreme (*e.g.* during el ENSO events). However, it is not well understood if subtle changes in sea surface temperature affect offspring health and survival. Additionally, besides direct mortality due to starvation is not well understood how changes in maternal attendance affect the health and survival of otariids. To investigate these questions, we assessed over a 10-year period the

satellite sea surface temperature data, the maternal attendance patterns and the immune and health parameters of South American fur seals (n=956) in a rookery where hookworm (*Uncinaria sp.*) disease is the main cause of pup mortality (Guafo Island, Northern Chilean Patagonia). Additionally, from 2012 through 2017 we performed field immune challenge and deworming experiments to explore pups' immune reactivity and hookworm pathogenesis and transmission dynamics. Pups receiving higher levels of maternal attendance had a positive energy balance and more reactive T lymphocytes. These pups were able to expel hookworms through a specific immune mechanism that involved proliferation of T lymphocytes and production of parasite specific IgG. This group of pups survived infection and recovered the weight lost due to hookworm infection by the end of the study. Pups that failed to mount an adaptive immune response died due to hookworm disease. Maternal attendance was lower in years with high sea surface temperature, therefore, the mean hookworm burden and mortality increased with sea surface temperature over a 10-year period. We provide a mechanistic explanation regarding how changes in ocean temperature and maternal care affect infectious diseases immunity, health and survival of a marine mammal.

Brachial plexus and segmental innervation of the forelimb in the Pacific white-sided dolphin (Lagenorhynchus obliquidens).

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When considering the dolphin evolution, actual morphological characters of target structures, which subject to the selective pressure, should be observed and described with extreme care.

We dissected both forelimbs of one Pacific white-sided dolphin to observe the brachial plexus morphology and nerve distribution to the flippers. Spinal segmental levels of the nerves were examined by the fascicle and fiber analyses.

The brachial plexuses were formed by the union of the ventral rami of the lower six cervical nerves and the first thoracic nerve. These roots fused with each other to form three trunks in the left cervical region and four trunks in the right. These trunks fused into a flattened nerve cords. At the axilla, the cords gave off nerves to supply muscles and skin of the flippers.

The phrenic nerve (C3-5) and the suprascapular nerve (C3-6) arose from the cranial margin of the plexuses. The pectoral nerves (C5-7) arose from the ventral surface of the plexus. In contrast, the dorsal scapular (C4), the subscapular (C4-7), the axillary (C4-7), and the radial (C5-8) nerves arose in turn from the dorsal surface of the brachial plexus. The median and ulnar nerves reached the forearm as a common trunk and gave off many cutaneous nerves for the skin of the flipper.

The boundary between the distribution areas of the median and ulnar nerves was on the third digit in the palmar side, and on the third digit or in the cleft between the third and fourth digits in the dorsal side. Most of the intrinsic muscles of the forelimb have degenerated except for some scapular muscles. The results of this study suggest that motor innervation has been lost in the flipper while the sensory nerve remains in the same pattern as that of the terrestrial mammal forelimb.

A comparison of Northeast Atlantic killer whale (Orcinus orca) stereotyped call repertoires

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Killer whale call repertoires can provide information on social connections among groups and populations. Killer whales in Iceland and Norway exhibit similar ecology and behaviour, are genetically related and were presumed to have been in contact prior to the collapse of the Atlanto-Scandian herring in the 1960s. However, a lack of photo-identification matches suggests no recent movements between these two locations. In contrast, part of the whales sighted in Iceland regularly travel to Shetland. Here, we used acoustic recordings collected between 2005-2016 in Iceland, Norway and Shetland to undertake a comprehensive comparison of call repertoires of Northeast Atlantic killer whales. Measurements of time and frequency parameters of calls from Iceland (n = 4037) and Norway (n = 1715) largely

overlapped in distribution, suggesting little differentiation between both populations, which was supported by a low correct classification rate in a discriminant function analysis. Due to a small sample size (n = 24), calls from Shetland were not included in quantitative analyses. Calls from Iceland were assigned to 74 call categories (43 call types and 31 subtypes). From Norway 54 call categories were described, (32 call types and 22 subtypes). Fifteen call categories (13 call types and 2 subtypes) from Shetland previously described in a separate study were also used. No call type matches were confirmed between Iceland and Norway or Shetland and Norway. Three call type matches between Iceland and Shetland were confirmed. Therefore, this study suggests overall similarities in time and frequency parameters but some divergence in call type repertoires. The call type matches between Iceland and Shetland but lack of matches to Norway support current knowledge of connectivity between the three locations. This stands in contrast to the presumed past contact between Icelandic and Norwegian killer whales and suggests that they may not have been one totally mixed population.

Interactions between killer whales (Orcinus orca) and the Patagonian toothfish (Dissostichus eleginoides) fishery at Crozet Archipelago: Insights from preliminary signature fatty acid analysis.

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Crozet Archipelago killer whales are known to feed on elephant seals, penguins, large whales, and to depredate Patagonian toothfish (*Dissostichus eleginoides)* from the local fishery. We used combined and complementary biochemical techniques to elucidate the trophic position of killer whales at Crozet Archipelago. Blubber biopsies of killer whales (*Orcinus orca),* sampled in proximity of the Patagonian toothfish fishery at Crozet, were analysed for signature fatty acids and amino acid compound- specific stable isotope analysis (CS-SIA). Potential prey species of killer whales were also analysed with a view to understand the diet of distinct killer whale social units in this area. Fatty acid profiles of fishery associated killer whales known to depredate longlines were distinct from the non-fishery associated killer whales. These differences were driven by six exogenous fatty acids (22:6ω3c (docosahexaenoic acid: DHA), 20:5ω3 (eicosapentaenoic acid: EPA), 20:1ω9c, 18:2ω6, 22:1ω11c, and 22:1ω9c). Fatty acid profiles of both fishery associated killer whales and Patagonian toothfish were also distinctly different, suggesting metabolic modification of fatty acids is taking place or an alternative non-sampled prey source is contributing, possibly juvenile toothfish. Trophic interactions between killer whales, elephant seals (*Mirounga leonina)* and potential prey fish species were inferred from fatty acids profiles, with the fatty acids data also suggesting a fish based diet for the non-fishery associated killer whale. We will also present CS-SIA using amino acids of killer whale biopsies (extracted blubber tissue) and potential killer whale food sources. The power of the CS-SIA approach lies in the differential fractionation of individual amino acids during trophic transfer. CS-SIA has allowed an examination of resource utilisation and trophic dynamics in the Crozet Archipelago.

The curiosity of metabolism of lipids in toothed whales; Multi-omics approach.

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Lipids in toothed whales are unusual compared to the other mammals. The lipid synthesis pathways in the suborder Odontoceti, the toothed whales might be evolved for various adaptations from the terrestrial environment to the marine environment like fast swimming, deep diving, feeding and echolocation. Therefore synthesis and function of these groups of endogenous lipids are still curious. In this study, we are focusing to identify possibilities of technologies to discover unsolved synthesis of lipid classes of wax esters and branched-chain fatty acids (BCFA) in toothed whales. In this review, various sources of information and literature were categorized into four major study areas of lipidomics, proteomics, transcriptomics and genomics. All the references were screened under each study area and finally possibilities to identify unusual lipid synthesis pathways of toothed whales were suggested for further investigations. In lipidomics studies, recent mass spectroscopic methods like HILIC and C30RP chromatography are identified to study neutral and phospholipids separately, however, determination of the structure of lipids is very challenging. As lipids interact with proteins in the animal body, lipidomics and proteomics need to be correlated by creating lipid-binding proteome maps

to easily understand metabolism pathways. Recent advances of Illumina Hiseq NGS of RNA and DNA helps to identify positive genes for the lipid metabolism in these animals. The results of this literature review concluded that a combination of four of these study areas can make a clear picture of curiosity of metabolism of lipids in toothed whales.

Fitness cost of food-provisioning on bottlenose dolphins can be related to an impoverished social environment.

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Tourism-oriented wildlife food-provisioning can profoundly impact the targeted species. In Bunbury, Western Australia, provisioned female bottlenose dolphins (*Tursiops aduncus*) suffer reduced reproductive success—only 38% of calves from provisioned females survive to three years of age while 77% of the calves from non-provisioned do (Senigaglia *et al*., accepted). However, the proximal causes for this long-term effect remains unknown. Using behavioural data from individual focal follows, we explore three hypotheses for how food-provisioning can lead to negative fitness consequences: 1) food-provisioning modifies behavioural budget (i.e. altered proportions of time foraging, travelling, socialising and resting); 2) provisioned females provide less maternal care to dependent offspring (i.e. calves spend less time in infant position); and 3) calves of provisioned females experience lower levels of sociality. Using Markov chain analyses, we found that provisioned dolphins spent less time socializing than non-provisioned dolphins. Using Generalised Linear Mixed effect Models, we found that the time calves spent in infant position was driven by their age and behavioural state but not whether their mothers were provisioned. By evaluating group size, social differentiation and social network centrality, we found that provisioned dolphins travel in smaller groups and have lower variability in their relationships, although females do not differ in number and strength of social associations. These findings indicate that food-provisioning can directly affect the social environment of the dolphins. The observed reduction in reproductive success of provisioned females may relate to the fact that their calves experience a modified, likely depauperate, social environment imposed by the mother's foraging strategy, rather than by reduced maternal care. Less time spent socializing can translate into fewer opportunities for calves to acquire proper foraging skills and to form social bonds that can improve their fitness. Our study strengthens the evidence that tourism can have short-term negative consequences that can affect fitness of wildlife.

Vulnerability of a marine top predator to coastal storms in central chile

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The frequency and intensity of coastal storms in Central Chile has increased in the last decades, affecting many species, including the South American sea lion (*Otaria byronia*). The breeding colony of Cobquecura, the most important for this species in central-south Chile, is highly exposed and it is located in front of a long sandy beach with no protection to ocean waves. In recent years, the stranding record of pups at the beach during the summer have notoriously increased, presumably due to the increase in the frequency and intensity of coastal storms. To validate this hypothesis, a database with historical sea states was built from the coupling of a generation wave model (WAVEWATCH III) and a coastal wave propagation model (STWAVE), in order to correlate the statistical wave parameters in the vicinity of the colony with stranding records of pups during summer, from 2009 to 2018. For the first half of January and the last of February, the comparison between the number of pups drowned per day have a low correlation with the wave period, the significant height wave and the normalized wave power parameters. These correlations significantly increases when compared wave parameters and pups stranded in the second half of January and the first of February. Three massive strandings in 2011, 2017 and 2018 coincide with normalized power values exceeding 100 m^2/s. Thus, the number of stranded pups is very sensitive to wave power above a certain threshold corresponding to extreme events. The

stranding records during intense coastal storms represent ca.10% of the annual birth rate at the Cobquecura colony, so they can have critical effects on the survival of the pups, and consequently on the population growth in the sector.

Comparison of photographic and observer-based aerial surveys for monitoring marine litter and mega-fauna

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Floating marine macro litter is known to cause severe environmental problems, particularly in closed seas where it may accumulate and threaten endangered marine fauna. Density and distribution of marine litter and mega-fauna (i.e. cetaceans, turtles and large fish) have traditionally been monitored through observer-based surveys, including aerial ones. However, the use of photographic-based methods has developed rapidly in recent years. To make possible the inclusion of new photographic-based results in previous data base, a validation of data collected through the two methods is needed. The aim of this study was to compare the observations obtained from the concurrent application of both methodologies during aerial surveys. Data were collected from four aerial surveys performed in March 2018 over the Spanish Mediterranean coast. Observer-based surveys covered 515.70 km^2 and allowed the detection of 472 targets. Photographic-based surveys covered 101.85 km^2, and 331 marine targets were detected in the 10,000 images collected. Both techniques allowed the identification of anthropogenic debris such as marine litter (i.e. plastic items), natural debris and mega-fauna. Results showed that marine mega-fauna densities obtained through the two methods were comparable, while floating marine macro-litter density was higher using the photographic-based method and birds density was higher using the observer-based one. The results of this study offer a first validation of the photographic-based method for monitoring floating marine macro-litter and mega-fauna.

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Humpback whale feeding call classification using sensory science-based techniques

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The sensory science discipline applies the principles of experimental design and statistical analysis to human senses (sound, sight, smell, taste, and touch) for the purposes of evaluating consumer products. These principles can be applied to just about anything that is perceived. Our linguistic ability makes humans particularly well suited for the task of analyzing humpback whale sounds, as they vocalize predominantly in the human frequency range and produce songs that are syntactical, rhyming, rapidly evolving and culturally transmitted. Here we apply sensory science methods to describe and classify humpback whale feeding calls. The goal is to develop additional objective measures for improved vocal fingerprinting and provide insight into pod leadership and task specialization. Feeding calls are used by North Pacific humpback whales to herd herring schools toward the surface. Unless foraging alone, it has not been possible to assign the calls to flukes, as calling typically occurs from individuals hidden in large, compact, subsurface groups. In this study, we recruit three groups of respondents (bio-acousticians, sensory scientists and musicians) for on-line interviews using the repertory grid methodology. The panelists evaluated 12 of 18 humpback whale bubble net calls in an incomplete block design of 4 triads. Data was analyzed by Generalized Procrustes Analysis (GPA) and frequency counts were utilized to generate consensus terms. Descriptors were derrived that contribute to call differentiation, including those already measured instrumentally and those likely to be most accurately measured by a trained panel. These techniques aim to improve communications between research groups via a well-developed lexicon and augment instrumental methods via new sensory measures.

White-beaked dolphin hotspot and seasonal site fidelity identified off Northumberland, North Sea

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White-beaked dolphin (*Lagenorhynchus albirostris*) occupying North Sea and UK waters are considered a separate management unit to other North Atlantic populations. The species is listed as a priority under the UK's Biodiversity Action Plan but limited data on population sub-structuring, distribution, abundance and movement have prevented effective conservation and management. To investigate suggested high sighting rates near the Farnes Deep glacial trench, North Sea, 36 opportunistic surveys were conducted between 2013 and 2018 during summer months. A total of 35 dolphin groups were encountered during which a diver recorded underwater video using GoPro Hero 3&4. Data on location, group size, group composition, foraging activity and association with other animals were collected.

Individual dolphins were photo-identified from high quality still frames using unique marks on the body, head and dorsal fin. Distinctive individuals were catalogued when both right and left sides of the individual were available. Sighting location data were projected in Arc GIS and 50 and 95 percentage volume contours (PVC) were created from kernel density estimation. Difference in group size between foraging and non-foraging groups and the relationship between group size and depth were investigated.

A total of 69 individuals were identified over the study, within year resightings were low but 22% were observed in more than 1 year, demonstrating some level of site fidelity. The 50 PVC contour covered a 13.8km^2 area located south of an area of deep water (>100m). Group size was significantly larger for foraging groups and foraging groups were often associated with gannets (*Morus bassanus*). There was no significant relationship between group size and depth.

This study highlights the importance of a relatively discreet area of the North Sea as important habitat for white-beaked dolphins. Foraging opportunity for epipelagic prey species may be an important driver for seasonal habitat use.

Behavioral responses of humpback whales (Megaptera novaeangliae) to approaching ships in Virginia Beach, Virginia, USA

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Ship strike mortality is a major conservation concern for humpback whales along the U.S. Atlantic coast. Nearly 90 humpbacks have stranded since 2016 and the National Oceanic and Atmospheric Administration has declared these strandings to be an Unusual Mortality Event; half of the necropsies show evidence of ship strikes or entanglement. One of the most intense conflicts occurs at the mouth of the Chesapeake Bay during winter, where the foraging area of juvenile humpback whales overlaps with shipping channels that are intensively used by large ships. Unlike other balaenopterid whales, humpbacks are "fight" rather than "flight" strategists when responding to predators, which could affect how they respond to other potential threats, such as approaching ships. In this project we are deploying digital sound and movement recording tags (DTAGs) and conducting focal follows of humpback whales, while simultaneously collecting Automatic Identification System (AIS) data from transiting vessels, to analyze the behavior of humpbacks during close ship approaches in the Virginia Beach shipping lanes. Eight tags were deployed in 2017 and two in 2019, with additional deployments planned in 2020. We will use fine-scale accelerometry from the DTAGs to determine if and how animals react to oncoming vessels, and, if so, at what distance or sound level threshold. We will examine how reactions vary with vessel distance, speed, and acoustic profile, to evaluate which ship characteristics elicit responses. We will also analyze whether the animal's behavioral state (foraging or non-foraging) affects their likelihood of response. Foraging behavior has not been described in this area, where juvenile humpbacks are foraging primarily on Atlantic menhaden *Brevoortia tyrannus* in extremely shallow water. Understanding the behavior of humpback whales around ships is critical to developing measures to reduce the risk of ship strike mortality and promote the recovery of this population.

A novel use of unoccupied aerial systems for 3-dimensional photogrammetry: Tracking grey seal maternal-offspring energy dynamics across lactation.

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Pinnipeds reliably haul-out on shore for pupping each year, accompanied by dramatic female-to-pup mass transfer over a short lactation period. This provides a particularly tractable study system for validating the use of unoccupied aerial systems (UAS; drones) as a completely non-invasive tool for tracking energy dynamics in wild populations. Here, we present a novel application of UAS technology for mass estimation, using fine-scale three-dimensional photogrammetry. In January 2019, we collected UAS imagery of grey seal (Halichoerus grypus) female-pup pairs at Saddle Island, Nova Scotia. A multirotor UAS was flown 360-degrees around study animals at ~20, 30, and 40-meter altitudes, and collected 53-231 photos at 0.43-0.80cm ground-sampling distance. For each flight, georeferenced images were stitched together for construction of a 3-dimensional point cloud, orthomosaic, and Digital Surface Model from which animal volume was measured (0.121-0.159 pixel reprojection error). Female-pup pairs were weighed directly following UAS survey (n=17 pairs), and a suite of morphometric measurements (lengths, heights, widths, girths, and blubber depths) were collected for determination of animal total body volume using a series of truncated cones (n=12 females). Both methods captured female mass loss (-5.3±1.2kg/day) and pup gains (+1.9±0.5kg/day) across the ~18-day lactation period. UAS-measured animal length and body volume measurements were within 1.8% and 8.4% of hand-measurements, respectively, and were not statistically-distinguishable. Moreover, UAS-measured body volume could accurately predict animal body mass ($P<0.001$; root-mean-square-error: 11.0kg or 5.8%). UAS images were also collected for ~70 additional female-pup pairs to begin characterizing volume and mass dynamics across lactation for a much larger sample size, working towards 'weighing the breeding colony'. To our knowledge, this is the first time that UAS has been used for 3-dimensional photogrammetry in any wild animal, and this method is likely to be widely-applicable across marine and terrestrial species.

Trends in strandings of dead California Sea Lions (Zalophus californianus) along the northern California coast, 1972 -2018

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California sea lions (*Zalophus californianus*, CSLs) are considered a sentinel species whose population status reflects the health of coastal California ecosystems. Using multiple data sets collected and maintained by the California Academy of Sciences (Level A Stranding Reports submitted to the Marine Mammal Health and Stranding Response Program database, the museum's collection catalog, and Fish & Game Marine Mammal Reports), we performed a preliminary analysis of dead-stranded CSLs (n=3127) reported near the San Francisco Bay Area from 1972 to 2018. Our goal was to describe trends within the data and explore how this long-term data set reflects CSL growth and spatial distribution at the population level. Stranding numbers generally increased throughout the forty-seven-year period, as is consistent with the steady increase in the total CSL population since the United States passed the Marine Mammal Protection Act in 1972. Males (n=2293) stranded in higher numbers than females (n=596) in every year analyzed, and female CSLs were rare in our response area until the mid 1990s when they began to strand regularly. Four peaks in sea lion strandings (1983, 1998, 2009, 2015) were observed during known El Niño and ocean warming events. These peaks remained after standardizing the data by population estimates, despite biases in the data set from variable and inconsistent effort over the years. In addition to demonstrating that these opportunistic records signaled when CSLs were impacted by large-scale oceanographic changes, these results highlight the importance of maintaining long-term records of marine mammal strandings. These baseline records will be essential to interpreting future sea lion stranding patterns and the response of the CSL population to environmental change.

Expansion of wintering ground of the humpback whales in the North Pacific: Beginning of the seasonal migration to around Hachijo Island, Izu Archipelago.

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Around Japan, it was considered that humpback whale (*Megaptera novaeangliae*) migrate to Okinawa (26°13'N, 127°41'E) and Bonin Islands (27°04'N, 142°13'E) for breeding. Hachijo Island (33°06'N, 139°47'E) is one of Izu Archipelago and located further north than those wintering grounds. In the winter of 2015/16, a number of humpback whales were confirmed around Hachijo Island, and a monitoring project of humpback whales around Hachijo Island has been initiated since the 2016/17 winter season. Here, we report the results of two subsequent year monitoring since the 2016/17 season with some new sporadic findings obtained from the 2018/19 season. We established track lines around the island, and whales were searched and photo-identified from a dedicated vessel (12t). The survey was carried out two times a month in average from November to April, totally 32 days in the first season and 34 days in the second. Humpback whales were sighted from November to March in the both seasons, and total sightings were 205 and 397 animals in the 2016/17 and 2017/18 seasons, respectively. Sightings per unit effort in the 2017/18 season (11.7 animals/day) was approximately twice as large as the first season (6.4 animals/day). Some individuals were photo-identified repeatedly during the same season, suggesting that the area is not just a migrating corridor but the one for other purposes to stay. Songs and competitive behaviors, relating to breeding activity, were recorded in the both seasons. In late March of the 2018/19 season, two pairs of mother and calf were confirmed, although it is unclear whether the calves were born around Hachijo Island or not. However, it seems appropriate to consider that Hachijo Island is their new wintering area. We should continue monitoring to further clarify the cause for humpback whales in the North Pacific to expand their wintering ground.

Seasonal characteristics of diving behavior of spotted seals in Rebun Island, Hokkaido, Japan

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Our previous research found that the adult spotted seals (*Phoca largha*) inhabiting Rebun Island, Hokkaido, Japan mainly breed in the sea-ice area of the Tatar Strait, and their breeding season is between January and April, and molt after April. However, how their diving behavior and the range change by various annual life events or the season has not yet been clarified. In this study, we aim to identify changes in the diving behavior of spotted seals equipped with satellite transmitters during their annual life events with relation to age class and sex. We used the finite mixture model and the regression was carried out using the R version 3.3.1 (R Core Team, 2016) and flexmix package version 2.3-13 (Gruen et al., 2015; Gruen and Leisch, 2008). It is a combination of two or more probability density functions. By combining the properties of the individual probability density functions, mixture models can approximate any arbitrary distribution. In this analysis, we created mixed models of dive duration and depth. As a result, during the breeding period in the Tatar Strait, the diving patterns of adult seals differed from the patterns before and after the breeding period. Both the adult female and male used the shallow water for a short time only during the breeding period. They probably limited their foraging behavior and hauled out frequently to devote themselves to breeding activity during the breeding period. Also, it is likely that the diving behavior of adult seals during the breeding period becomes passive. Furthermore, the female conducted deeper and longer dives before the breeding period than the male. This is probably because females need to accumulate more energy resource than males in order to maintain the growth of their fetus and prepare giving birth and nursing.

Distribution and habitat of deep diving predators, sperm (Physeter macrocephalus) and Baird's beaked whales (Berardius bairdii), around Hokkaido, Japan

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Sperm whale (SW) and Baird's beaked whale (BBW) coming around Hokkaido, northern Japan in Autumn, have similar feeding habits; feeding depth and diets. Previous sighting surveys conducted in North Pacific off Honshu showed that BBWs distribute nearer coast than SWs, however, it is unclear how both species segregate around Hokkaido. In this study, we conducted sighting survey in Autumn around Hokkaido, in order to quantify habitat preference of SW and BBW. Sighting surveys were conducted from the T/S Ushio-maru (Hokkaido university) in September and October (2009-2018) in the Pacific coast of Hokkaido (PCH) and the Nemuro Strait. Their habitats were estimated using software Maxent with five factors; depth, slope, distance from coast and, distance from 1000- and 3000-m isobath. Off PCH, SWs were found in the Kushiro Submarine Canyon, whereas BBWs were found in the Hidaka Bay. There were significant differences in slope and distance from 3000-m isobath. SWs were observed in steeper, closer to 3000-m isobath area than BBWs. As results of habitat estimation, SWs were predicted to be distributed in 800-3000m depth, while BBWs were predicted to be only in the Hidaka Bay. This prediction of SWs distribution was caused by the Kushiro Submarine Canyon. Difference between two species distribution was probably affected by their migration routes. BBWs were distributed on the continental shelf off northeastern Honshu, and migrate northward to the Hidaka Bay along 1000-m isobath. While SWs migrate northward from offshore isobath (> 3000-m isobath) to Kushiro Submarine Canyon. In the Nemuro Strait, both species were observed in the northern area, where steep slope deeper than 2400 m exists in the north-central part. There were no significant differences in environmental factors. Therefore, the different distribution of these species off PCH may be caused by distance of their most prefered isobath.

Investigation for the helminthic parasites of odontocetes using stranded/by-caught individuals in Japan.

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Helminth parasites of cetaceans are usually studied on stranded or by-caught individuals, and the helminth studies are scarce in Asia. In this study, the odontocetes stranded or by-caught in Japanese coasts were examined and the helminth fauna was investigated. Totally 194 individuals of 11 species were collected during the year 2012 to 2019 (narrow-ridged finless porpoise, harbor porpoise, striped dolphin, spinner dolphin, bottlenose dolphin, Indo-pacific bottlenose dolphin, melon-headed whale, Risso's dolphin, false killer whale, pygmy sperm whale, and dwarf sperm whale). The cranial air sinuses, lungs, liver, stomach, and intestine were observed macroscopically, then washed and precipitations were inspected under stereomicroscope to collect helminthes. 11 species of nematodes: *Anisakis* spp., *Crassicauda grampicola*, *Halocercus lagenorhynchi*, *H. pingi*, *H. sunameri*, *Pharurus asiaeorientalis*, *P. sunameri*, *Stenurus globicephalae*, *S. minor*, *S. nanjingensis*, and *Torynurus convolutus*; 11 trematodes: *Brachycladium nipponicum*, *Brachycladium* sp., *Campula oblonga*, *Nasitrema globicephalae*, *N. gondo*, *N. spathulatum*, *N. sunameri*, *Nasitrema* sp., *Oschmarinella laevicaecum*, *Synthesium nipponicum*, *S. tursionis*; 2 cestodes: *Diphyllobothrium* sp., *Tetrabothrius* spp. and 2 acanthocephalans: *Bolbosoma* spp., *Corynosoma* sp. were found. Many of the helminthes of narrow-ridged finless porpoise (*H. pingi*, *H. sunameri*, *P. asiaeorientalis*, *P. sunameri*, *S. nanjingensis*, *N. spathulatum*, and *N. sunameri*) were host-specific. Finless porpoises (genus *Neophocaena*) are distributed in Asian coastal waters, thus these helminthes are limited to Japanese or Asian waters. Three species (*B. nipponicum*, *N. gondo*, and *O. laevicaecum*), which are rarely found in previous studies in areas other than Japan, were found from the delphinid hosts. *N. gondo* and *Brachycladium* sp. were in cranial air sinuses and liver of dwarf sperm whale. The latter might be an undescribed species and this is the first record of trematodes from the genus *Kogia*. The helminth fauna in Japanese waters was suggested to be characterized by several endemic species.

NOAA and navy sound monitoring in sanctuaries

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As part of a settlement agreement, the U.S. National Oceanographic and Atmospheric Administration (NOAA) and the U.S. Navy are engaged in a multi-year effort to monitor underwater sound within the U.S. National Marine

Sanctuary System. The agencies are working with numerous scientific partners to study sound within seven national marine sanctuaries and one marine national monument, including waters off the U.S. east coast, west coast and Hawaiian archipelago. The project is designed to provide standardized baseline information important for contextualizing both how much sound is introduced within these protected areas by specific sources and the potential for each type of source to impact the areas' marine taxa and habitats.

The agencies selected approximately 30 recording locations where sound conditions and acoustically sensitive species are of management interest. Regional teams began deployment rotations using identical, temporary bottom-mounted sensors at these locations in fall 2018. Recording efforts will continue for 3 to 4 years. Collaboration with partners will make use of other technologies and existing acoustic recordings at locations where further time series or comparisons are of interest.

To inform the project's development, the agencies sponsored an expert workshop in May 2018. Workshop participants emphasized standardized approaches to facilitate comparison in soundscape attributes among international projects with longer-term and larger-scale monitoring focus. Discussions also highlighted the importance of defining ecologically meaningful measures and producing visualization methods that can support both management processes and public communication. These recommendations have guided the project's priorities and work to develop analysis techniques for characterizing both the overall sound levels and specific contributions from marine animals, physical processes and human activities. Unprocessed data will be archived and made publicly available through NOAA's National Center for Environmental Information. A web portal for further access and exploration of products is also under development.

Using subsistence-harvested bowhead whale baleen as a multi-decadal contaminant recorder

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Potentially harmful concentrations of heavy metals have been recorded in marine mammals as far north as the Arctic Beaufort Sea. Bowhead whales (*Balaena mysticetus*) annually migrate from their winter foraging grounds of the Bering Sea into the Chukchi Sea and eastward to the Beaufort Sea (summer). A single baleen plate from a bowhead whale grows continuously and can store more than 20 years of dietary and, subsequently, environmental data. Analysis of heavy metals in western Arctic bowhead whale baleen plates, via atomic absorption spectrophotometry, confirmed successful detection of twelve heavy metals (Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, V, Zn). Baleen plates obtained from subsistence-harvested bowhead whales between 1966 and 1999 were analyzed, providing first-ever heavy metal data from 1947-1999. Previous stable carbon and nitrogen isotope analyses from the same baleen of these whales ascertained the general locations and seasons (Beaufort Sea in summer/fall; Bering/Chukchi seas in winter/spring) along the western Arctic population's migration path. Comparing heavy metal concentrations to the respective stable isotope values of the same sample allowed concentrations to be attributed to general season and region. There were significant differences among elements ($X^2(11)=341.44$, $p=<2.2e-16$), with copper, vanadium, and zinc having the highest average concentrations (338 ppm, 835 ppm, 226 ppm, respectively), and cadmium, chromium, and manganese having the lowest (4 ppm, 2 ppm, 3 ppm, respectively). All metal concentrations fluctuated temporally, but did not increase nor decrease over time. Seasonally, nickel and zinc were highest in winter and spring (Bering and Chukchi seas), while mercury was generally highest in summer and fall (Beaufort Sea).

Estimating work and power during a controlled swimming task

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How efficiently marine mammals swim directly affects oxygen management and determines both dive duration and activity levels that can be maintained. Therefore, an understanding of energetic cost during these behaviors is critical for determining the physiological (and thus behavioral) envelope of diving animals, and the consequences of anthropogenic stressors on their fitness.

However, direct measurements of energetic cost or external forces (thrust for propulsion or drag on the body) are challenging to obtain in swimming animals. While recent work has been conducted to directly measure thrust created by swimming bottlenose dolphins using particle image velocimetry, these studies are limited by camera-based kinematic data collection in controlled environments. Such a method is not practical for use with wild animals. As such, energetic expenditures of free-swimming whales and dolphins can be estimated only by using proxies such as heart rate, respiration rate or body acceleration, though experimental validation of these proxies has been limited. Our research seeks to create the knowledge necessary to estimate mechanical work, a key contributor to the overall metabolic cost of free-swimming cetaceans. Here we present results that combine data from multi-sensor tags, an overhead camera, and models of drag to estimate per-lap work and power. These estimates were evaluated in a controlled experimental environment with managed animals during prescribed swimming tasks. Six animals swam a ~63 m lap at regular and fast swimming speeds. The analysis used data from 14.7 km (233 laps) of straight-line swimming to calculate per-lap work and power during active swimming. The animals had an average speed of 3 m/s (0.6 SD) with average lap speeds ranging from 1.7-4.7 m/s. The resulting fit of speed to power, $P(u)=13.5u^{3.5}$, was both significant ($Adj.\ R^2 = 0.80$) and compares well to published values in the literature.

Using marine mammal key habitats for developing a Pan-Arctic network of Marine Protected Areas

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Rapidly changing Arctic presents challenges for conservationists and environmental managers. One of the most effective ways to protect the biological diversity and ecological processes of the marine environment is to design an ecologically connected and representative network of conservation areas. *Pan-Arctic marine protected area network* (PAMPAN) project, initiated by WWF, aims at designing a network of priority areas for conservation (PACs) using integrated ecosystem approach. Marine mammals (MM) are the top predators in the Arctic ecosystems. Assessing and mapping their key habitats plays a fundamental role in defining PACs. Twenty-seven MM species encountered in the project area were selected. We have collected best available up-to-date information on the areas (and, where possible, core-areas) important for MMs, such as breeding and feeding grounds, molting, whelping patches, haul-outs, polar bear denning sites. In total, 235 data layers were created for different stocks or "geographic variations" of MM species across the Arctic. Conservation target was assigned to each data layer based on the formula, which considered IUCN conservation status of the unit, whether the species is full-year Arctic resident, seasonal resident or a visitor, its biomass, importance to Arctic ecosystem, importance to indigenous and coastal communities. A series of expert-advised spatial analyses using a decision-support tool Marxan was conducted to define PACs. For the purpose of PAMPAN, MM data were integrated into the dataset containing similarly collected data on birds, fish, plankton and benthic communities. As a result, a network of geographically and ecologically connected representative PACs was produced using systematic, transparent and reproducible method, based on best available data. In current work, we show how MM data contributed to the results of analysis, and how the designed network could contribute to MM conservation in the Arctic.

Leucism in Brazilian dolphins: A phenotypic trait associated to specific populations?

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Leucism is defined as a total lack of pigmentation throughout the entire body. This type of

hypopigmentation occurs despite the normal production of the enzyme tyrosinase and melanin, as no melanin deposition occurs in skin cells, hair follicles or feathers, due to an inherited defect in the pigment transfer process. Leucism can be caused by one of several different mutations and gives rise to seemingly similar phenotypes. Thus, leucistic animals are white or whitish all over but have normally colored eyes. The very rare occurrence of leucistic individuals is normally due to the mating of two heterozygous, normal-colored individuals each carrying a rare, recessive leucism allele. Recently, in Brazil, cases of anomalously white dolphins have been reported, involving one juvenile rough-toothed dolphin (*Steno bredanensis*), as well as recurrent cases in Guiana dolphins (*Sotalia guianensis*). The leucistic *S. bredanensis* was reported off Ilhabela, São Paulo, on 9 December 2017. In addition to this single record of an anomalously white-pigmented *S. bredanensis* in Brazilian waters, photograph comparisons of previously catalogued individuals suggest a common hypopigmentation pattern, *i.e.*, whitish patches throughout large portions of the body, observed off the coasts of São Paulo and Rio de Janeiro, SE Brazil. It is generally believed that leucistic animals present reduced fitness, perhaps due to higher predation risks or pleiotropic effects on other physiological functions. However, although often reported as a deleterious trait, adult leucistic dolphins have been reported globally in cetaceans, from cold to tropical waters. As such, as evidenced in two coastal species of dolphins off Brazil, this study provides evidence of maintenance of geographical color variations in small cetacean populations in a particular habitat or area. Further investigations concerning the prevalence of such an anomalous coloration in coastal dolphin populations are essential for assessing the prevalence of leucistic individuals in this habitat.

Acoustic examination of non-song call production as a function of humpback whale (Megaptera novaeangliae) pod composition and subsurface behavior in Hawaii.

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Despite the dominance of male song in the humpback whale communication research literature, increasing attention has been paid to non-song calls. However, relatively few studies have examined these calls in the humpback whale breeding grounds, and currently there are no descriptions of call characteristics in conjunction with underwater video in non-calf pods. Thus, little is known about the relationships between non-song calls, pod type, and subsurface behavior during adult interactions such as mate competition or stationary pair associations. This study characterizes call types in relation to pod type and composition, sea state, and behavioral state. The dataset consisted of subsurface video and audio recordings from an archival database collected from humpback whales in different pod types in waters off Maui from 1998-2007. Video and audio data were recorded using a mini-DV camera in an underwater housing outfitted with a single uncalibrated hydrophone (useable system response: 7Hz ≥ 20kHz). Calls were manually identified in spectrograms in Raven Pro, and cluster analysis was used to classify call types. Approximately 75 hours of acoustic recordings containing non-song calls were analyzed. Over the study period, 1,533 pods were recorded and 372 (24%) pods were found to contain non-song calls. Of these 372 pods, competitive pods were found to contain non-song calls more frequently than any other pod type (53%), followed by dyads (19%) and mother-calf escort pods (17%) with all other pod types accounting for only 11%. Non-song sound production may be important for male-male aggressive interactions, or female communication with potential mates. The results of this study will allow for comparisons in behavioral usage between non-song call types in Hawaii and other populations with already established call types in very different behavioral contexts across the wide geographical range of this species.

Beaked whale (Hyperoodon ampullatus) body condition and the starvation-predation trade-off

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The starvation-predation trade-off is vital to an animal's fitness. Central to how animals balance foraging against predation risk is energy store body condition: animals in poor condition should accept greater predation risk to maximise foraging gain. Such state-dependent risk-taking concepts are well-established; however few studies have assessed how body condition influences the starvation-predation trade-off in marine mammals. We investigated if beaked whales exchange foraging

for anti-predation behaviour and whether body condition drives this trade-off, as predicted by the starvation-predation trade-off and state-dependent theory. Using hydrodynamic models, tissue body density (an indicator of lipid energy store) was estimated for 15 northern bottlenose whales tagged with DTags near Jan Mayen. Measures of foraging (diving, echolocation clicks, prey capture attempts) and anti-predation (shallow ascents, silence near the surface) behaviours were combined as composite indices of foraging and anti-predation. Increased foraging index predicted a decreased anti-predation index (slope=-.43, $t(13)$=-3.66, p<.01); indicating that predator avoidance decreased when foraging increased, consistent with the starvation-predation trade-off. Anti-predation indices increased and foraging indices greatly decreased after sonar exposures (n=3). There was strong support for tissue body density as a predictor of the ratio of the anti-predation index to the foraging index. Increased tissue body density (a lower proportion of fat) predicted an increased ratio of anti-predation to foraging behaviour (slope=.23, $t(13)$=2.68, p<.02). Despite a small sample size, this indicates that animals with poorer body condition took fewer predation risks and foraged less, contrary to state-dependent decision-making theory. Given animals in better condition foraged more, body condition could be a consequence, rather than driver, of behaviour. Body condition might drive behaviour at more extremes of condition than were observed here. Bottlenose whales were heavily affected by whaling, and our results indicate that a perceived anthropogenic threat (sonar) may increase predation avoidance behaviour and reduce foraging, exaggerating foraging-predation risk trade-offs.

Electronic camera monitoring of harbour porpoise (Phocoena phocoena) bycatch in bottom-set gillnet fishery: A matter of perspective.

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In this study we present the results of an assessment of bycatch of harbour porpoise (*Phocoena phocoena*) in the Dutch commercial bottom-set gillnet fishery using Remote Electronic Monitoring (REM). We focus in particular on the challenges encountered, how we dealt with them (both successful and unsuccessful) and provide advice based on our experience.

This project was initiated by two ministry departments, fishery and nature conservation, following guidance from the Dutch Harbour porpoise conservation plan. A total of fourteen fishing vessels participated voluntarily. For the study period (1 June 2013 to 31 March 2017) 900 fishing days of 8133 fishing days of the overall fleet (11%) were analysed. Bycatches occurred in both single-walled gillnets (GNS) and trammel nets (GTR), with an average annual mortality of 23 porpoises (95% C.I. 2-44).

REM provides valuable data for bycatch monitoring, particularly on smaller vessels. However, the limitations of space mean it intrudes on the privacy of the crew and installation options are restricted. During the study technical and non-technical challenges continuously emerged, leading to a critical project stage within the first year. However, through a number of interventions these difficulties could be resolved and over the next five years the project turned into an example of a successful cooperation between scientists, fishermen and the government.

Analyses of the project procedure highlighted that the main issues were not logistical challenges but instead intrinsic (traditional believes) and extrinsic (changes in policy) factors that influenced the perspectives of the stakeholders in combination with inadequate communication and an atmosphere of distrust.

A successful cooperation is only possible when each other's perspectives are understood and respected. Planning an REM project with a small scale fishing community needs to include as much effort and attention to ensure effective communication as much as the challenges of collecting and analysing the data.

Testing of two commercially available porpoise bycatch reduction devices in a Sub-Arctic bottom set gillnet fishery

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Various sound based devices have been designed to reduce bycatch of porpoises in gillnet fisheries, and several such products are available commercially.

Such devices have not been tested or used in the Icelandic set gillnet fishery for cod, which has some bycatch of marine mammals, predominantly of harbour porpoise. In this study, we tested two devices, one "pinger" and one "porpoise alert device" in the Icelandic cod gillnet fishery. Three commercial vessels were used for the experiment, in three regions were most bycatch had been observed in the past. Each of the devices were tested for a week in each region, and in each region 3-4 paired 0.4 nautical mile long sets of nets were set, where half of the sets were deployed with the devices according to the manufacturer's description, and the other half acted as a control.

In the pinger trial, eleven cetaceans were caught, nine harbour porpoises, and two white beaked dolphins. Six of those cetaceans were caught in the pinger sets, while 5 animals were caught in the control, suggesting no effect of the pinger on bycatch rates. The size and gender composition of the bycaught animals was similar between the two treatments, and no difference in the catch of fish was observed.

In the porpoise alert device trial, 23 harbour porpoises were caught, but no other cetaceans. Twelve porpoises were caught in nets with the alert devices, while eleven were caught in the control sets, suggesting no effect on bycatch rates. Interestingly, eleven out of twelve porpoises caught in the device sets were large adult males, while the gender ratio was six males to five females in the control sets. Eight of those males in the device sets were caught right by the device, suggesting possible attraction of adult male porpoises towards the device.

High collocation between humpback whales and sand lance in the southwestern Gulf of Maine

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The abundance and distribution of forage fishes can have major impacts on the abundance and distribution of marine mammals. In the Gulf of Maine (USA), a preferred prey of humpback whales is sand lance (*Ammodytes* spp.). General fluctuations in humpback whale abundance in the southwestern Gulf of Maine have been correlated with shifts in sand lance abundance, but overlap between whales and sand lance on a fine spatial scale has not been investigated. We explored spatial relationships between humpback whales and sand lance in Stellwagen Bank National Marine Sanctuary, an important humpback feeding area in the southwestern Gulf of Maine. Counts of sand lance and humpback whales were conducted at 44 sites in spring and fall from 2013-2018. We used spatial metrics and collocation indices to quantify overlap between humpback whales and sand lance at two spatial scales (site-level (local) ~1 km and sanctuary-level (global) ~2180 km^2) and developed a hierarchical Bayesian model to predict humpback whale density based on sand lance density. Based on collocation indices ranging from 0 (no co-occurrence) to 1 (local -- species density proportional at sites; global -- population centers coincide), we found weak collocation between sand lance and whales at the site-level (local index range: 0 - 0.28), but strong collocation at the sanctuary-level (global index range: 0.7-0.98). Preliminary model results suggest humpback whale density increases with sand lance density and also varies with season and region within the sanctuary. Our results suggest humpback distributions can be tightly linked with sand lance abundance and that long-term changes in sand lance abundance could impact ecosystem structure and the effectiveness of the sanctuary in contributing to the fitness of humpback whales. Our work also provides context for understanding potential species distribution shifts due to climate change, and for predicting acute whale-human conflicts in space and time.

The occurrence and behaviour of harbour porpoises around Scottish salmon farms

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The nature and extent of interactions between cetaceans and aquaculture are largely unexplored, a key knowledge gap**.** Potential interactions may represent a trade-off between foraging opportunities and exposure to industry activities. In

Scotland, Atlantic salmon (*Salmo salar*) farming industry is mainly on the west coast, northern and western islands, waters that host some of the highest densities of harbour porpoise (*Phocoena phocoena*) in Europe. The aim of this study was to determine when and how often porpoises approach fish farms on Scotland's west coast. Passive Acoustic Monitoring (PAM) for porpoise echolocation using SoundTraps and C-PODs was undertaken at seven farms and nearby navigation buoys. Hydrophone arrays were deployed to understand the fine-scale movement and behaviour of porpoises around farm infrastructure. The fish farm soundscape was recorded to identify noise characteristics emitted by industry activities. Wild fish aggregations around farms were surveyed through video recordings and sonar to establish if they may be prey for porpoises. Results indicate porpoises are found around salmon farms, but presence varies between locations and may be dependent on time of day, tidal state, site bathymetry, and farm activity. Frequent detections and the occurrence of feeding buzzes suggest that porpoises forage around farms. Soundscape analysis revealed distinctive acoustic characteristics of activities such as fish feeding, electricity generators, acoustic deterrent devices (ADDs), and net cleaning. The significant background noise associated with these activities affected C-PODs through masking, clipping and sensitivity loss, and subsequent bespoke configurations successfully optimised the recorders. The present study affirms that interactions between aquaculture and porpoises commonly occur on the west coast of Scotland, and that farms may represent a foraging resource. The precise nature of the relationships between industry infrastructure, farmed salmon, discarded salmon feed, wild fish and porpoises remain to be investigated.

Sex differences in skin marks patterns in common bottlenose dolphins (Tursiops truncatus).

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Cetaceans frequently display skin marks which can be caused by diseases, parasites, and interactions among conspecifics and with human activities. For the present study, we used one year of photo-identification data for resident bottlenose dolphins of the Ría de Arousa (NW Spain). The aims of this study were to assess the types of skin marks found on bottlenose dolphins and compare them between adult males and females. Four body sections (anterior, ventral, central and posterior) were defined to assess the prevalence, abundance, richness, and distribution of the marks. Boat-based surveys were carried out on 65 days between January and October 2017 for a duration of 352 hours, with 218 groups of dolphins observed during 98 hours. A total of 178 individuals were identified, and 21 adult sexed individuals (12 males and 9 females) were used for the analysis. Social-induced marks (tooth-rakes, nicks, and linear marks) and skin disorders (diseases and parasites) were observed, but none of the individuals showed human-induced injuries. All skin marks, except parasitic marks, were found on all individuals. The abundance of marks was higher in males (mean ± SD = 130.7 ± 20.7) than in females (mean ± SD = 88.3 ± 17.5). The richness in tooth-rakes was significantly higher in males, while the richness in skin disease marks were significantly higher in females. Skin mark types were dependent on body section, with the posterior section exhibiting the most skin marks for all individuals. The differences in social-induced skin marks between the sexes may be explained by behavioural variation, with males exhibiting more aggressive and agonistic behaviour than females. These results show that photo-identification provides an efficient approach to recording body marks in bottlenose dolphin as a way to understand the social behaviour of this species.

Predator controls: Lessons from land to sea. A comparison of how marine and terrestrial mammals are managed in human-wildlife conflict scenarios in Europe.

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Wild animals come into conflict with humans in Europe in a number of circumstances and, although both marine and terrestrial mammal predators are involved in such conflicts, their situations are rarely compared. The predation of livestock and other animals reared for human use, such as farmed fish, is a key area of conflict and predators are managed in a variety of ways to prevent them from injuring and killing these animals. Other areas of human-wildlife conflict include the perceived competition for wild prey (for example lynx and wolves competing with hunters for deer, and seals competing with fishermen for salmon). We compare methods of conflict reduction used for terrestrial large carnivores (bear, wolf, wolverine, lynx) and marine mammals (seals). Both lethal and

non-lethal management methods are considered. Areas where lessons can be learned from experiences on land are identified for their potential to guide conflict reduction in the marine environment. We also consider how control methods are chosen. In some cases, the most effective method is not always the one that is implemented and factors such as practicality, cultural norms, cost effectiveness and others may strongly influence the methods used. We highlight the importance of carrying out humaneness assessments to ensure that the control methods that are chosen are as humane as possible so that animal welfare is not negatively impacted. Potential humaneness assessment protocols are presented and a call to further develop these for wildlife control is made.

Marine mammals, sound and the Global Ocean Observing System: Implementing a globally sustained observing system for these essential ocean variables.

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The Biology and Ecosystem Panel of the Global Ocean Observing System (UNESCO/IOC/GOOS) is responsible for identifying Essential Ocean Variables (EOVs) for biological components of the oceans and supporting their observation in a globally sustained system. Increased and better focused ocean observations supported in a sustained way by the international scientific, governance and policy communities are needed to (a) globally determine and monitor appropriate trade-offs between conservation and sustainable use, (b) effectively mitigate or manage adverse changes including climate change, and (c) predict and prepare for potential future changes. Here we focus on two of the EOVs identified by the panel: "marine mammal abundance and distribution" and "ocean sound." We present how these EOVs are specified and describe work being done to establish a framework that will allow development of globally sustained observation systems for each EOV, including identifying existing networks or programs aggregating relevant data. We invite community input from the marine mammalogy audience on this framework and the implementation timeline, and seek partners interested in contributing observations or shaping the implementation process. Our aim is to build on existing efforts to achieve a globally standardized, open access and sustained observing system which will deliver societal benefits by contributing to the UN Decade of Ocean Science and informing national reporting activities such as the World Ocean Assessment, Sustainable Development Goal 14, and updated Aichi targets, among others. Observations from the system will also support a new treaty for conservation and sustainable use of marine biodiversity beyond national jurisdiction and organizations managing activities in these regions.

Are there relationships between contaminant exposure and gene transcripts or metabolite profiles in the endangered St. Lawrence Estuary beluga (Delphinapterus leucas) population?

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Belugas from the St. Lawrence Estuary population in Canada are highly contaminated. It has been postulated that exposure to elevated concentrations of polychlorinated biphenyls (PCBs), chlorinated pesticides and flame retardants (polybrominated diphenyl ethers (PBDEs) and emerging compounds) might play a role in the non-recovery of this endangered population. *In vitro* and *in vivo* studies of mammals have shown that PCBs, PBDEs and chlorinated pesticides can perturb the homeostasis of circulating thyroid and steroid hormones, or alter the expression of genes involved in their regulation. A growing number of studies also indicate that endocrine disrupting compounds may be linked to metabolic disorders, and that amino acids and fatty acids could be used as biomarkers. In this study, a suite of organic contaminants (i.e., PCBs, chlorinated pesticides, short-chained chlorinated paraffins (SCCPs),

PBDEs, and emerging flame retardants) was measured in blubber biopsy samples obtained from 40 free-ranging male St. Lawrence Estuary belugas to examine their link with the regulation of endocrine or metabolic axes. Contaminant concentrations were related to 10 gene transcripts (thyroid and steroid regulation and metabolism of pollutants) and profiles of a suite of metabolites (21 amino acids, 22 biogenic amines, 18 fatty acids, and 17 energy metabolites) measured in skin biopsy samples by RT-qPCR and HPLC, respectively. Concentrations of several contaminants (PCBs, organochlorine pesticides and emerging compounds) correlated with the transcription of steroid- and/or thyroid-related genes (*Esrα*, *Dio2*, *Hsd11β2*, *Nr3c1* and *Thrβ*). SCCP concentrations also correlated with fatty acid profiles (C16:1n7, C18:0, C18:1n9, C20:5n3 and C22:5n6). Several biological functions including growth, development, reproduction, and energetic metabolism may be related to contaminant exposure in this population. Results further indicated that the use of omics represents a valuable screening tool to assess the impacts of environmental contaminants in cetaceans.

Co-occurrence of beaked whale strandings and naval sonar in the Mariana Islands, Western Pacific.

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Mid-frequency active sonar (MFAS), used for antisubmarine warfare (ASW), has been associated with multiple mass stranding events of beaked whales. International naval exercises using ASW have been conducted in the Mariana Islands semi-annually since 2006. We report beaked whale acoustic activity detected from two acoustic recorders deployed off Saipan and Tinian (Mariana Islands) from March 2010 through November 2014. Signals from Cuvier's (*Ziphius cavirostris)* and Blainville's beaked whales (*Mesoplodon densirostris*), and a third unidentified beaked whale species were detected throughout the recording period. Both recorders documented the presence of MFAS on 21 August 2011 before two Cuvier's beaked whales were discovered stranded on 22-23 August 2011. We compared the history of known naval operations and beaked whale strandings from Guam and Saipan to consider potential threats to these whale populations. Between June 2006 – January 2019 four of eight beaked whale strandings occurred during, or within 6 days after naval activities. A simulation suggests that the probability that these four strandings were randomly associated with naval events is 0.1%. We highlight the importance of ongoing passive acoustic monitoring, especially for beaked whales that are difficult to visually detect at sea, and monitoring beaches for stranded cetaceans before, during, and after naval exercises.

Mesoscale dynamics of blue and fin whales and Antarctic krill off East Antarctica

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Blue and fin whales occur seasonally in the Southern Ocean to forage, primarily on Antarctic krill. These species are typically found in different pelagic environments, with blue whales often associated with sea ice and fin whales occupying areas away from sea ice. When they co-occur, however, it is not known if they compete over the same type and size of krill swarms, or if they have distinct swarm size, density, or krill life stage preferences. We investigated co-occurrence of blue and fin whales and krill in an open water area off East Antarctica using a bottom-moored passive acoustic recorder and an echosounder over one week in early February 2019. Using only calls with high signal-to-noise ratios, we measured whale occurrence in the vicinity of the moored recorders. Fin whale 20 Hz and 40 Hz calls were commonly recorded during the first four days, but almost entirely absent during the last three days. Blue whale song and D calls, on the other hand, were persistent during the first six days, but substantially decreased on the seventh day. Both 40 Hz and D calls were more common than songs for both species, possibly indicative of social and foraging behaviors. The distribution and abundance of acoustically-detected krill varied throughout the

study period. Dense backscatter layers at 20-40 m depths were common during the first three days, but they were largely absent in subsequent days, replaced by more dispersed layers. On the sixth day, a dense, shallow backscatter layer appeared and coincided with an increase in blue whale D calls and fin whale 40 Hz calls. Backscatter substantially decreased after that event, coinciding with the cessation in detection of calls by either species. These data shed light on foraging preferences of these two large krill consumers in the Antarctic ecosystem.

Identification of discrete and persistent high density offshore areas of mobile marine mammals – lessons learnt from the selection of potential EU special areas of conservation for harbour porpoise in the UK

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The EC "Habitats Directive" requires Member States to contribute to a coherent European ecological network of protected sites through designation of Special Areas of Conservation (SACs) for species (and habitats) listed on its Annexes. Site identification is based on Directive criteria, including evidence of physical and biological factors essential to these species' life and reproduction. While some wide-ranging highly mobile aquatic species have clearly-defined breeding/nurturing/feeding areas, the harbour porpoise *Phocoena phocoena* does not. The Joint Nature Conservation Committee and DHI undertook a detailed statistical analysis of 18 years of survey data collated through the Joint Cetacean Protocol (JCP) to identify discrete and persistent areas of relatively high harbour porpoise density within the UK Exclusive Economic Zone. This presentation describes the modelling framework developed, and discusses the challenges and solutions to circumvent the potential bias introduced by the spatio-temporally skewed multi-platform survey data. Although JCP comprised data from at least 545 distinct ship and aircraft surveys different parts of UK waters have received a variable survey coverage over the 18 years. Consequently, many areas have been surveyed on few occasions making reliable predicted estimates of yearly distributions a challenge. Additionally, smaller areas typically associated with marine wind farm development have received intensive spatial survey coverage but over relatively short periods of time which could give rise to mean densities becoming biased in these areas. To address these challenges dynamic distribution models capable of making predictions based on oceanographic conditions, sediment characteristics, shipping intensity and "three-dimensional" space-time smoothers were developed. The model results indicate that densities of harbour porpoises are influenced by both oceanographic and anthropogenic pressure variables. A number of areas with predicted persistent high densities of porpoises were identified by the study and underpinned the identification of the SACs. Four of these are the largest SACs ever designated in Europe.

Where are those Maui dolphins?

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An individual-based model was used to analyse the movements and distribution of Maui dolphin *(Cephalorhynchus hectori maui)*. For each run of the model, simulated movements were compared with field data. The resulting Goodness-of-Fit estimates were used to calibrate the model. The number of 1 kilometre moves per hour varies for each dolphin and every hour in the model. The number of moves per hour follows a Poisson distribution which the scaling exponent μ. This resulted in movements that approximate a Weibull distribution, resulting in a very good fit to the field data. The dolphins' depth preferences follow a sigmoid function: $(1 + 0.01^{1-d/\delta})^{-1}$ where d is water depth (in metres) and δ is the depth-preference exponent. We used a simple step function for the dolphins' schooling preference, with dolphins moving to a new location at each time step with preference = 1 if there are no dolphins present and 1+ σ if there are other dolphins present in the new location. After calibration, the best fitting parameters were: Movement exponent μ = 5.1, depth preference δ = 50, home range exponent η = 27.5 and schooling preference σ = 322. The resulting maps of Maui dolphin distribution show considerable overlap with gillnet and trawl fisheries. We recommend adjusting the boundaries for protected areas in which gillnets and/or trawling is banned, to provide more effective protection. Recommendations by the International Whaling Commission (IWC) and IUCN are included in the set of management options. The IWC has

recommended extending protection to 20 nautical miles offshore for Maui dolphins. The IUCN has recommended extending protection to the 100 metre depth contour for both Maui and Hector's dolphins. The New Zealand government is currently considering improvements to the protection of Maui and Hector's dolphins, with a decision expected in August 2019.

Particle motion in vocalizations of the endangered North Atlantic right whale (Eubalaena glacialis) and humpback whale (Megaptera novaeangliae): Implications for communication and anthropogenic noise impacts.

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It has been hypothesized that mysticetes hear and utilize the particle motion component of sound for communication, similar to some other large mammals with low-frequency ears. However, most research on mysticete communication has focused on the pressure component of acoustic signals and overlooked the paired particle motion component. The goal of this project is to investigate the particle motion component of vocalizations from multiple mysticete species. We deployed an M20 Particle Velocity Sensor (GeoSpectrum, Inc) near vocalizing individuals to measure and describe acoustic particle velocity and pressure generated by vocalizations from two mysticete species; endangered North Atlantic right whales (*Eubalaena glacialis*) in Cape Cod Bay, Massachusetts, and singing male humpback whales (*Megaptera novaeangliae*) near Maui, Hawaii. A total of 42 gunshot and upsweep calls were recorded from *E. glacialis* in 2018, and over 1000 song units were recording from *M. novaeangliae* in 2016. Both *E. glacialis* and *M. novaeangliae* produced acoustic fields with considerable received particle velocity magnitudes (-125 to -95 dB re: 1 m/s at distances up to 423 m) which contained directional information available to conspecifics. Particle velocity magnitudes attenuated at a similar rate to acoustic pressure, thereby also providing an available distance cue. Additionally, opportunistic recordings showed that small neighboring ocean vessels also generated particle motion components of -109 to -111 dB re: 1 m/s at a distance of 700 meters. Although mysticete hearing is largely unstudied, these vibratory particle components may play a role in auditory reception by stimulating bone conduction to the ears. These results indicate particle motion is a possible pathway for acoustic communication in mysticetes that has been largely unexplored and could be a valuable component of understanding potential impacts of anthropogenic noise, particularly for endangered species such as *E. glacialis.*

River and Ocean Guardians Protect Endangered Cetaceans in Asia

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Fatal entanglement in gillnets is the most critical threat facing small cetaceans. A promising conservation approach entails engaging fishers as river and ocean guardians. In the Mekong River, Cambodia, fishers are engaged as river guardian to enforce the ban on gillnets threatening a critically endangered population of Irrawaddy dolphins. In coastal waters of Bangladesh gillnet fishermen are engaged to release cetaceans, turtles and whale sharks found alive in their nets and record geo-referenced data on catches used to establish new marine protected areas and as part of a spatial planning process to optimize protecting threatened marine wildlife with sustainable fisheries.

Permanent placement trends and survivorship of stranded, non-releasable marine mammals

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The National Marine Fisheries Service (NMFS) Marine Mammal Stranding Network program attempts to successfully rehabilitate and release back to the wild each stranded marine mammal that is admitted into rehabilitation, as intended by the Marine Mammal Protection Act. However, in some cases, the attending veterinarian of the rehabilitation facility may determine that the release of a rehabilitated marine mammal is unlikely to be successful given the physical condition, age, and/or behavior of the animal, as

outlined in the NMFS Marine Mammal Release Criteria. In these cases, NMFS may deem the marine mammals non-releasable and subsequently place themwith a permanent care facility for the purposes of public display, research, or national defense. We evaluated more than 150 individual placements, representing 13 unique species (4 cetaceans and 9 pinnipeds), over a seven-year period (2012-2018) and identified leading causes for non-releasable determinations (e.g., physical condition, age, or behavioral), factors influencing placement timelines, and survivorship of marine mammals following permanent placement. Results from this study will be used to inform stranding partners, placement facilities, and NMFS managers regarding future rehabilitation and placement efforts.

New diagnostic techniques to characterize fetal, placental, and maternal health in bottlenose dolphins following the Deepwater Horizon oil spill

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In the aftermath of the *Deepwater Horizon* (DWH) disaster, a high rate of reproductive failure persists in bottlenose dolphins (*Tursiops truncatus*) living within the oil spill footprint. Proposed causes include poor maternal health, direct oil-related toxic effects to the reproductive system or fetus, complications related to adrenal system dysfunction, and/or immune system perturbations leading to increased susceptibility to reproductive pathogens. To better characterize reproductive health, new diagnostic techniques were developed with dolphins in human care and applied to free-ranging dolphins living in oil-impacted Barataria Bay, LA (BB). An expanded reproductive ultrasound protocol was developed to evaluate fetal, placental, and maternal health; diagnose fetal and placental disease; and potentially predict reproductive outcome. To establish measurements and descriptive findings correlated with reproductive success, serial ultrasonographic evaluations were performed with 12 dolphins in human care during 16 successful pregnancies (2010-2017). A total of 203 ultrasound exams were included, measuring up to 70 parameters per scan. Fetal biparietal diameter (BPD), thoracic width in dorsal and transverse planes, thoracic height in a sagittal plane, aortic diameter, and blubber thickness were correlated with date of gestation (r^2>0.94, P<0.001). A refined equation for prediction of parturition date in bottlenose dolphins was developed [days to parturition = 348.16-(26.03*BPD(cm)) (r^2=0.99)]. Regional uteroplacental thickness significantly increased with each trimester (range 0.22-0.40cm; P<0.001 cranial and caudal uterus; P<0.001 mid-uterus). To evaluate fetal lung health, the lung:liver echogenicity ratio was established as 2.57 (95% CI = 2.47-2.67). The protocol was applied to BB dolphin pregnancy exams (N=38) performed during capture-release health assessments (2011-2018). Fetal and placental abnormalities were detected with ultrasound examination, including fetal distress, placentitis, and umbilical cord torsion. Ultrasound findings will be combined with additional measures of reproductive health to help elucidate etiologies of pregnancy failure in BB dolphins.

Impacts of shipping on a humpback whale breeding ground in a multiple use Marine Park: The Great Barrier Reef.

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The Australian east coast population of humpback whales (E1 sub-population) annually migrate to the Great Barrier Reef (GBR) for mating and calving, an area where there is a high level of co-occurrence between shipping and whales. Here we assess the distribution of mating and calving areas in the GBR

Marine Park (GBRMP; an area of 344,400 km^2) and quantify the risk of ship strike and cumulative ship noise to humpback whales at a spatial scale appropriate for risk assessment frameworks. Using a combination of aerial surveys and satellite tag data, we identify for the first time the migration and breeding grounds and a clear demarcation between core calving and mating areas. The core area (> 90% predicted density) for groups with calves constituted > 90% of ship strike risk and was situated in a different area to the core area for non-calf groups of high (> 90%) ship strike risk. Calf groups had a higher relative risk of ship strike compared to non-calf groups (when standardised for group size) and we demonstrate a change in the distribution of calf groups to near-shore areas over the breeding season, resulting in increased exposure to shipping traffic. Using source spectra measurements of large vessel noise, we calculated significant levels of noise exposure on singing humpback whales based on their auditory sensitivity threshold. These results clearly identify core areas of breeding humpback whales, which overlap with the inner shipping route and pose the greatest risk of ship strike and effects from noise. 'Special Management Areas' (SMA) are a potential legislative tool for regulating human activities on the whale's breeding ground, although currently no SMA exists but could now be implemented. A 'Whale Protection Area' does exist, primarily to manage whale tourism operations, although does not cover the core mating and calving areas identified.

Mitochondrial genetics of narwhals (Monodon monoceros): A study in a minimally destructive method of ancient DNA extraction in narwhal tusk material.

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Narwhals, *Monodon monoceros,* are elusive animals, and have inspired myths, legends, and awe for centuries, which is exacerbated by their inaccessibility in the heavily iced high Canadian Arctic waters. With a current "Near Threatened" classification by the International Union for Conservation of Nature and Natural Resources (IUCN) and a total population estimate of roughly 80,000 animals, unlocking the genetic code of this species may be the key to beginning to unravel much of the mystery that surrounds them, both in the past and the future. This study aims to provide a reliable, minimally destructive method to extract ancient narwhal DNA from samples that wish to remain physically unmarred for display purposes. Short pieces of unprocessed pre-1972 narwhal tusk (n=50) have been obtained by the author from Pond Inlet, Nunavet Canada. This study utilized narwhal cytochrome *b* mitochondrial gene data from the National Center for Biotechnology Information's (NCBI) GenBank, where two primers, NAR-4 (581 bp) and NAR-6 (241 bp), were created for use in this study during Polymerase Chain Reaction (PCR). Using a grinding technique on the tusk surface, the study outlines a reliable method to extract ancient deoxyribonucleic acid (DNA) from narwhal tusk and amplify it for further analysis using PCR. The amplified DNA from the grinding method was compared to the traditional drilling method using electrophoresis and demonstrated that the grinding method yields the same level of amplification level of DNA as the drilling method. The extracted DNA was then sequenced using the designed primers and compared to narwhal mitochondrial gene samples in GenBank to positively confirm narwhal tusk sample's identity. This study's grinding technique showed significant reduction in physical marring to the surface of the narwhal tusk samples and provides evidence for a reliable method to extract ancient narwhal DNA while preserving historical samples for unmarred display.

Shifting focus: Using stable isotope analyses to distinguish carbon sources of Alaskan polar bears.

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We analyzed collagen stable isotopes of two Alaska polar bear (*Ursus maritimus*) subpopulations over the past 60 years. The Southern Beaufort Sea (SBS) polar bear subpopulation is declining in response to sea ice loss, while the Chukchi Sea (CS) subpopulation appears stable. We used polar bear bones from 1954–2018 provided by the University of Alaska Museum and samples collected by Native subsistence hunters. We developed a stable isotope timeline of bone collagen to explore polar bear carbon sourcing within the SBS and CS subpopulations, e.g., switch from marine to terrestrial carbon. A total of 104 samples were extracted for bone collagen and analyzed for bulk $\delta^{13}C$ and $\delta^{15}N$. In addition, we analyzed collagen for compound-specific stable isotopes of

amino acids (AA). Our aim was to determine if there is a shift towards more terrestrial carbon sources following the North Pacific regime shift of 1976/77 and after a major Arctic sea ice minimum of 2007. After Suess correction, CS and SBS bears had significantly different bulk $\delta^{13}C$ (-13.0±0.6‰ and -14.8±1.1‰, respectively) that was mirrored in phenylalanine $\delta^{13}C$ (-20.2±2.4‰ and -24.5±1.3‰, respectively) speaking to different primary production baselines in the two ecosystems. Bulk $\delta^{13}C$ and $\delta^{15}N$ of SBS bears declined over the 60-year period by 2‰ and 1‰, respectively. $\delta^{13}C$ of glycine of SBS bears significantly declined (before 76/77 (B): -7.5±2.7‰; after 76/77 (A1): -9.9±4.1‰; after 2007 (A2): -23.2±1.2‰), as did serine (B: 0.9±4.7‰; A1: -4.2±4.1‰; A2: -12.6±3.0‰), and isoleucine (B: -14.0±1.2‰; A1: -15.3±2.0‰; A2: -17.9±2.2‰). Polar bear values after the regime shift closely reflect or approach those of brown bears (*Ursus arctos*) sampled from the coastal Beaufort Sea from 1960–2005 (glycine: -26.0±1.7‰; serine: -7.1±2.0‰; isoleucine: -24.2±1.7‰). Together with published accounts on $\delta^{13}C$ values of AA in aquatic and terrestrial foodwebs, our results suggest a gradual increase of terrestrial carbon in polar bear diets.

Osmoregulation and electrolyte balance in a fully marine mammal, the dugong (Dugong dugon).

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Dugongs (*Dugong dugon*) are fully marine mammals that live entirely independently of fresh water, but little is known about how they regulate water and electrolyte balance in a hyperosmotic environment. To investigate the osmoregulatory capabilities of dugongs, osmolality and electrolyte (Na^+ and K^+) concentrations were measured in matched plasma and urine samples collected from 51 live wild dugongs in Moreton Bay, Australia. Maximum values for urine osmolality (1468 mOsm kg^{-1}) and Na^+ and K^+ concentrations (757 mmol L^{-1} and 131.3 mmol L^{-1}, respectively) indicate that dugongs are capable of concentrating urine above seawater and could potentially realise a net gain of free water from mariposia (the drinking of seawater). However, mean urine osmolality of 932.57 (± 46.29) mOsm kg^{-1} suggests that mariposia is unlikely to be an important osmoregulatory mechanism. Dugongs may obtain enough preformed water from their seagrass diet and through metabolic oxidation to maintain homeostasis in the absence of fresh water. Mean plasma osmolality was 339.46 (± 1.75) mOsm kg^{-1}, which is higher than in manatees but within the range reported for fully marine cetaceans. Relatively high mean plasma Na^+ (175.19 ± 1.72 mmol L^{-1}) and K^+ (6.9 ± 0.1 mmol L^{-1}) concentrations, as well as mean urinary Na^+ (469.55 ± 22.05 mmol L^{-1}) and K^+ (32.17 ± 4.46 mmol L^{-1}) concentrations were observed and can possibly be explained by the dugong's diet of salt-rich seagrasses. Pregnant females had higher mean plasma osmolality (355.3 ± 4.9 mmol L^{-1}) than males and non-pregnant females (337.9 ± 1.7 mOsm kg^{-1}), suggesting that fluid retention was not a feature of pregnancy, however, no evidence of electrolyte retention was found. Further research is required to better understand water and electrolyte balance in this species, including differences observed between population cohorts.

Analysis of growth layer groups in harp seal (Pagophilus groenlandicus) teeth reveals temporal changes in stable isotope ratios.

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Changes in the trophic level of apex predators can reflect variations in the availability and quality of food resources, with pinnipeds widely used as indicator species for marine conditions in polar regions. Harp seals (*Pagophilus groenlandicus*) are the most abundant pinniped in the North Atlantic and remove appreciable quantities of commercial fish prey, along with crustaceans e.g. amphipods associated with the ice edge. The diet of foraging seals is expected to reflect the local food web baseline. Satellite telemetry shows harp seals travelling between subarctic and Arctic waters, suggesting that their foraging success may depend on them integrating conditions across wide geographic areas during their seasonal migrations.

The chemical and mineral composition of tooth dentine is stable over time, potentially providing a through-ontogeny archive of seal diet. Dentine (containing collagen) is deposited annually, and can be subdivided into clear growth layer groups (GLGs). We describe a methodology whereby collagen from harp seal teeth GLGs can be separated and analysed to allow age and year specific estimates of stable isotope ratios ($d^{13}C$

and $d^{15}N$). We present initial results from the analysis of historical archives of harp seal teeth from the North West Atlantic and from the Barents Sea (East Ice). Individual variation between animals is pronounced, but temporal variation in both populations is detectable despite this 'noise' in the data. The North West Atlantic harp seal teeth show significant differences in stable isotope ratios for $d^{13}C$ and $d^{15}N$ between decades (1981, 1991 and 2001). Harp seal teeth from the East Ice in the Barents Sea also revealed significant temporal trends in $d^{13}C$ and $d^{15}N$ from 1950 to 2000. Given substantial environmental change in the Arctic region, these observed changes may be caused by shifts in the baseline, the food web structure, or both.

Review of specific night vision technologies for cetacean detection

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Data are sparse on specific model, specification, and cost- and at-sea effectiveness of vision-enhancing devices for detecting cetaceans during low-light conditions (e.g., darkness). We identified, evaluated, and compared 15 specific vision-enhancing devices used or useful to meet U.S. regulatory requirements for marine mammal mitigation/monitoring during low-light periods of offshore wind development activities for Ørsted and Deepwater Wind in the U.S. Atlantic. Evaluation focused on cetacean detection at distances of 200, 500 and 1000 m from a vessel. Information compiled included available literature, personal communications with experts, our own in-field results and internet searches of equipment. Results indicate that for regulated zones <200 m in radius, recently used specific hand-held infra-red (IR) and hand-held light-enhancing devices are considered reasonably effective. At distances of 200-500+ m, more expensive yet reasonably priced mounted IR devices providing automatic detection software, image stabilization, remote display, and/or delineation of mitigation zones improve objective mitigation decision-making and alleviate observer eye strain associated with handheld devices. Multiple camera use and video or still image review capability improve sighting effectiveness and reduce false negative indications. Device performance is influenced by weather conditions (e.g., fog, rain). Our field results indicated that mounted IR cameras detected whales and delphinid groups 2+ km away in good conditions (low sea state, minimal ambient light, clear conditions). Newly available devices should be reviewed on a continuum to identify improvements/affordability. Testing of night/low-light vision devices via controlled systematic studies is needed for regions where offshore wind development and operations occur during low-light conditions, focusing on seasons and areas where sample sizes of cetacean visual detections can be maximized. Compilation and statistical comparisons of our field data with data already collected using such devices during other U.S. Atlantic marine mammal monitoring is highly recommended to examine robustness and effectiveness under various conditions.

Guiana dolphin skin disorders as proxies for short-term anthropogenic disturbances in port areas

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Anthropogenic activities can impact the marine ecosystems functioning and biodiversity health. Port areas are of particular concern for marine megafauna due to the typical intense boat traffic and sources of noise and chemical pollution. The synergistic effect of such disturbances can lead to increased stress levels and immunological depression in marine animals, decreasing their overall health. In cetaceans, poor health status can be visually detected as skin diseases and lesions. Here we compare such visual cues of health status in Guiana dolphins, *Sotalia guianensis*, inhabiting one of the largest port areas in southern Brazil and an adjacent marine conservation area. From 18 daily surveys actively searching for Guiana dolphins, we encountered 70 groups (33 in the port, 37 in the protected area) and photographed their dorsal fins for individual identification and all their body visible above water to investigate skin lesions and diseases. After cataloguing all groups, we compared all skin lesions with those reported in the literature for cetaceans. The most common skin diseases were lobomycosis-like and nodules, and the most common lesion of intraspecific

interactions were tooth marks, while the most common lesion of possibly infectious were hyperpigmentation and hypopigmentation. We found that resident dolphins from the port area showed proportionally higher evidence of skin diseases and lesions associated (70%), while dolphins resident in the protected area showed only lesions (51%). While revealing a causal relationship between anthropogenic activities, skin diseases, and health status requires future research, our current findings suggest that the port areas may indeed pose a higher risk to the dolphins' health.

Pseudomonas stutzeri and Candida spp. isolated from blowhole samples and associated with free-ranging killer whale (Orcinus orca) in coastal waters of Kamchatka Peninsula.

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Experts in marine biology face the challenge of finding ways to assess the health risks of free-ranging populations of cetaceans. One possible solution is to conduct research into the interactions and relationships between hosts and their microbiota, revealing the relationship between many aspects of host's biology, health and associated microorganisms. In this connection, killer whale blowhole samples was conducted in the area of Starichkov Isl., Far East, Russia in August 2018. One individual of killer whale was identified - AV062 – "Ikar". Microbiota was sampled in sterile Petri dishes according to the Karina A. Acevedo-Whitehouse method. Then blowhole samples was transported by sterile tubes with Amie's bacterial transport medium with activated carbon that to remove bacterial waste products. Also, bacterial water control of same area was conducted directly during blowhole sampling. Bacterial seeding was carried out on culture media: meat-peptone agar, meat-peptone broth, blood agar, Endo agar, mash agar, Czapek-Dox agar. Isolated pure bacterial cultures were identified by a mass-spectrometer Microflex Brucker Daltonik MALDI Biotyper, BRUKER, Germany. As a result, *P. stutzeri* and *Candida spp.* were identified. *P. stutzeri* is a nonfluorescent denitrifying bacterium widely distributed in the environment. *P. stutzeri* strains have natural transformation properties, making it relevant for study of the transfer of genes in the environment. *P. stutzeri* several strains are able to fix dinitrogen and others participate in the degradation of pollutants or interact with toxic metals. Also may be isolated as an opportunistic pathogen from different species of *Mammalia*. The obtained data can be used for comparative characteristics with microbiota isolated from killer whales contained in captivity for correct diagnosis in case of disease. Potential pathogens of significance to humans and other species of animals were recovered.

Gulf of Mexico Bryde's whales in the Northwestern Gulf: Call variation and occurrence.

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The Gulf of Mexico (GOM) Bryde's whale, the only year-round resident baleen whale in the GOM, currently has an estimated abundance of 33 whales, is found within a restricted range along the northeastern GOM shelfbreak, and was recently listed by NMFS as endangered under the Endangered Species Act. Human activities such as oil and gas exploration and extraction, fisheries, and shipping in the GOM could pose additional risk to this already small population, and it is necessary to better understand their distribution and ecology. While current sightings are rare, historical whaling records suggest Bryde's whales range may have included the northwestern and northcentral GOM, and it is unknown whether or not they currently occupy these areas. Use of autonomous passive acoustic methods are the best tool for finding rare whale species where they occur infrequently and where they have been historically sighted. To determine if the whales occur beyond the northeastern GOM, acoustic recording packages (ARPs) were deployed at five shelfbreak sites in the northwestern and northcentral GOM from July 2016 to May

2017. By manually reviewing long-term spectral averages, individual calls were detected, and hourly and daily occurrence and number of calls were derived for each site. High quality ARP recordings were obtained for the complete deployment period at four sites and over 1500 novel stereotyped tonal calls were detected. These calls appear to be variants of the long-moan call produced by GOM Bryde's whales in the northeastern GOM. Calls were detected on 12% of days at the westernmost site and call detections decreased heading east across sites. Seasonality was not evident. This information is crucial for understanding GOM Bryde's whale distribution and will be useful in designating critical habitat and determining whether human activities pose a risk to this species.

Hydrostatic analysis to design a buoyancy prosthesis for a negatively-buoyant West Indian manatee (Trichechus manatus).

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The West Indian manatee is endangered due to anthropogenic activity, most often in the USA due to water-craft collisions. If the animal survives the collision, they are commonly scared or permanently injured, as in the case of a subadult Florida manatee rescued and rehabilitated in 2008, but with a permanent negatively buoyancy condition due to scar tissue in the caudal section of its right lung, thus not a candidate for release. Other than this condition, the animal is healthy and has been able to compensate to breath at the surface in a shallow water tank under human care. To enhance his general welfare under human care, we seek to develop an appropriate prosthesis to bring back his neutral floatation capacity and allow him to swim normally in the water column. To accomplished this, it was necessary to calculate the current position of manatee's center of gravity (CG) and center of buoyancy (CB), as it is understood that both CG and CB have suffered some displacement in this particular manatee as compensation to his negatively buoyant condition. We investigated this by means of hydrostatic analysis using data from necropsies performed in manatees in Puerto Rico and morphometric data from manatee itself. The density of the manatee was obtained using two methods, the water displacement method, and a cinematic/dynamic analysis. The model described in previous literature was applied to obtain the position of the CG and the CB of the manatee. In addition, to compare the results obtained, the manatee was modeled using the SolidWorks software to obtain the CB. In the case of CG, the second method used was by obtaining the net torque. With this information, a study of the characteristics of possible materials for the construction of the prosthesis and a tentative design was conducted, and is here presented.

Movements of three species of seals tagged in 2013-2014 in the Okhotsk Sea.

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True seals (Phocidae) remain poorly studied in Russian seas. From 2013-2014 we installed satellite transmitters on 10 bearded (Erignathus barbatus), 5 ringed (Pusa hispida) and 2 largha (Phoca largha) seals in the Sakhalin Bay of the Okhotsk Sea, an area and adjacent waters of eastern Sakhalin characterized by high anthropogenic load (fishing and oil production).

All animals resided close to the tagging site during summer and autumn and almost all movements were restricted to waters of shallow depth, less than 20 m deep. With the onset of early fast ice formation, ringed and largha seals moved away to areas not yet covered with ice. In contrast, bearded seals, did not avoid ice, changing their resting ground from land to ice. This behavior relates to the benthic feeding of bearded seals in shallow waters. With increased ice formation, bearded and ringed seals were almost never recorded in waters deeper than 100 m, excluding one region: during migrations along the eastern coast of i. Sakhalin all animals move around oil platforms in deeper waters. In ice period, all three species of seals preferred one-year ice of high concentration.

To study population structures of seals in Okhotsk Sea, it is necessary to understand the relationship between feeding and reproductive areas. Both tagged larghas spent the winter in the region of the known reproductive area in the Tatar Strait. Bearded seals were registered in Sakhalin Bay and on northern and eastern coasts of i. Sakhalin. Key

habitats of ringed seals were located in all the above regions.

Thus, dynamics of the ice formation determined migration times between seasonal areas for all three species. Water depth had the strongest influence on seasonal habitat choice for bearded seals, while for largha and ringed seals the presence and type of ice cover was the key factor.

Population structure and patterns of habitat use of sperm whales in the Gulf of Mexico revealed by seven years of passive acoustic monitoring

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The Gulf of Mexico is an important habitat for globally endangered sperm whales (*Physeter macrocephalus*), which may use the region as a breeding or nursing ground. Their population structure and seasonal movements in the Gulf are poorly understood. Presence of sperm whale echolocation clicks was documented in nearly continuous passive acoustic recordings collected at three long term monitoring sites in the Gulf from 2010 to 2017. Sperm whales show strong sexual dimorphism in body size, therefore a method was developed to determine population structure using the distribution of distinct inter-click intervals (ICI) and correlated with inter-pulse intervals (IPI) as a proxy for body size. The inter-pulse intervals were converted into size categories using an established method for estimating animal acoustic length and further correlated to the inter-click intervals. Distribution of inter-click intervals were compared across sites and over time. Three different classes were found, one with a mean ICI and IPI of 0.8 s and 4.6 ms respectively, which corresponds to adult males, a second with mean ICI and IPI of 0.6 s and 3.6 ms respectively, which corresponds to social units of sperm whales (mixed groups with adult females and their offspring), and a third class with mean ICI and IPI of 0.7 s and 4 ms respectively is believed to contain adult females and sub-adult males. A majority of detections consisted of small females and mid-sized animals. The mixed group was present all year at two northern sites in the Gulf but was only seasonally present at one southern site. In contrast, only three percent of observations consisted of adult males, which were occasionally present throughout the year at the two northern sites. This supports the prior hypotheses that the Gulf of Mexico may be an important location for sperm whale reproduction.

Skin conditions and body anomalies of humpback whales, Megaptera novaeangliae in Sainte-Marie channel (North east of Madagascar).

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Skin lesions are frequent in cetacean populations worldwide and we describe the occurrence of skin conditions in mysticete whales among the Western Indian Ocean Region. Cetacean skin lesions are studied from photo-identifications, strandings, and by-catch data. We assess skin lesions from 4858 photos of humpback whales *Megaptera novaeangliae*, taken near Sainte-Marie, Madagascar, during 2012 and 2013. Our study found 286 clinical cases of individuals with one or more types of skin lesion and we detected 7 different types of skin conditions. The skin conditions observed and body anomalies observed include : pigmentation anomalies (35%), skin lesions (47%), parasitic infection (6%), deformities (9%), and miscellaneous traumata (2%). These conditions were observed on all parts of the body and some individuals had multiple occurrences of conditions. Our results also suggest that all group type of humpback whale can be affected by different skin diseases. This study demonstrates that photo-id data offers a non-invasive, cost-effective approach to study disease in wild cetacean populations. Further, while many skin diseases are not considered fatal, lesions detected on free-ranging animals may serve as indicators of other health concerns or environmental threats. Our study increases the knowledge and understanding of diseases and abnormalities in cetaceans in the Western Indian Ocean Region.

Acoustic properties of male sperm whale (Physeter macrocephalus) slow clicks with implications for their function.

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Sound is the primary sensory modality of cetaceans, enabling navigation, prey detection, predator avoidance and communication. Whereas some toothed whales employ different sounds for

different functions, such as whistles for communication and clicks for echolocation, others such as sperm whales (*Physeter macrocephalus*) use clicks to fulfil both functions. Sperm whales produce at least four types of clicks or click sequences; usual clicks, buzzes, codas and slow clicks. Interestingly, the latter is only produced by males suggesting a communicative function of sexual display, but not much is known about the acoustic properties of slow clicks and their implications for function. We tested the hypothesis that slow clicks are used for long-range communication of size in male sperm whales by quantifying the acoustic properties of slow clicks from a close encounter with a male sperm whale emitting slow clicks in the proximity of a group of females off the coast of the Seychelles. The male produced numerous multi-pulsed slow clicks (N = 66) at known (measured with a range finder) ranges from the hydrophone at a mean apparent source level of 201±8 dB re 1µPa peak-peak (up to 229 dB re 1µPa peak-peak), a mean centroid frequency of 5.2±1.2 kHz and a mean inter-click-interval of 4.8±0.1 seconds. While previous findings have proposed that the inter-pulse-interval may allow females and other males to assess the size of the male source, the multi-pulse structure will not travel far, limiting such assessment to short ranges. Slow clicks have the lowest frequency emphasis of any sperm whale click and instead, we therefore suggest that females may choose males by selecting for those producing slow clicks of the lowest frequency. Thus, males may be producing an honest signalling of size when emitting slow clicks, being constrained by their size, and hence the size of their sound-producing organ.

Developing shared socioeconomic pathways for whale watching to support climate impact assessments in European islands

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Climate change is altering chemical, physical and biological processes in the marine environment, further exacerbating environmental pressures on ecosystems and interfering with human activities and economic sectors related to the Blue Economy. The need for methodologies that improve our understanding of climate impacts, vulnerabilities and risks has led to the development of the Shared Socioeconomic Pathways (SSPs), a new scenario framework describing a set of alternative future trends in the evolution of the environment and society. In our work narrative scenarios were extended to whale watching, aiming to serve as input to a set of climate impacts, vulnerability and adaptation assessments and ultimately as part of a decision support tool for this sector. Four whale watching SSP narratives were developed from the European scale SSPs through the identification and description of key elements relevant for the activity. The SSPs elements and assumptions were validated by experts and local stakeholders, namely whale watching companies. The extended whale watching SSPs were regionally assessed for the Macaronesia Atlantic region. Current and projected trends for each element were then evaluated through expert judgment elicitation methods and further quantified using available socioeconomic data. The consistent and harmonized narrative scenarios for whale watching in the Atlantic region are intended to assist comparability across study areas and to be combined with Representative Concentration Pathways (RCPs). This will produce the basis for an integrated scenario analysis and the development of future climate adaptation and biodiversity conservation measures across European Islands.

Behavior of humpback whale singers in the Abrolhos Bank, Brazil

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The Abrolhos Bank (AB) is located off the East coast of Brazil where approximately 80% of all humpback whales that visit the coast of Brazil concentrate. Social dynamics in this region are thought to enable reproduction and calving as well as mediate sexual selection. Males use complex vocal displays to mediate intra- and inter-sexual interactions. Using different arrays of synchronized marine recorder units (MARUs) between 2003 and

2005, we were able to estimate the localization of multiple singers in short time intervals, which allowed us to count them and trace their trajectories in fine scale. This way we could visualize when males concentrate their singing activity, how and where singers move, the characteristics of their trajectories, if they interact among themselves and with vessels. Singing activity at AB is high. In a 391-h recording at the beginning of the reproductive season in 2005, more than 90% of the hours showed singing activity of at least two males simultaneously. Models were able to identify two distinct movement patterns in singers: slow, short and uniform steps lengths which suggests an exploratory behavioral state interpolated by rare fast and long steps which characterize a directional movement. Motivation for switching between behavioral states probably involves decisions about optimal reproductive strategies. There is an increase in the number of males singing as the season progresses even though the number of individuals present in the AB decreases after a mid-season peak. The overall temporal pattern in singing activity shows a decrease in song detection in the middle of the day in all years where vessel traffic is present, whereas in a quieter area, song was detected continuously. Noise from boat engines that may compromise humpback whale communication apparently elicits a reorganization of the timing of male vocal displays to avoid acoustic competition with the noise.

The song of the humpback whale (Megaptera novaeangliae) in the Abrolhos Bank across 18 years

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The Abrolhos Bank off Brazil receives, during every austral winter and spring, humpback whales that are thought to reproduce and calve in the region. During this period males present vocal displays that are considered one of the most complex behaviours in nature: the song. It is comprised of long repetitive patterns structured hierarchically into units, phrases and themes. Each population converges to a specific version of the song that changes over time in variable rates. Given the recovery of the stock A of humpback whales, we were interested in tracking the song versions across time, defining the song structure from 2000 to 2018 and comparing the inter-annual variation of themes sung in the Abrolhos Bank. Recordings were made from vessels while monitoring the behaviour of individual males. Sounds were acquired using portable recorders at a sampling rate of 48kHz for at least 20 minutes. In order to quantify the annual changes in song structure, we calculated song similarity using the Levenshtein distance following the most recent methods described in the literature. The results enabled verifying song cultural evolution in small temporal scale when comparing consecutive years, and medium temporal scale when assessing a longer time interval (2000 to 2018). Inter- and intra-individual variation were found in different hierarchical levels of the song: unit, phrases and themes, probably reflecting the dynamics of the species' sexual selection process. Qualitative analyses showed different rates of change in the song over the years, demonstrating no single pattern. These results indicate that song cultural evolution within the population that visits Abrolhos is not directed by a single force driving this phenomenon.

To eat of not to eat: tradeoff between food and fear in fecal ingestion from communal latrines of a semi-aquatic mammal

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Communal latrines have important biological and ecological roles for the latrine builder species and for other taxa that visit these sites and use feces to obtain nutrients and microorganisms that aid in digestion of compounds hard to process. Nonetheless, coprophagous animals must deal with the costs associated with parasites and other pathogens present in the latrines. Parasites and pathogens are found in Neotropical otter latrines. This species is piscivorous and uses latrines for territorial marking. The objective of this study was to identify vertebrate species

associated with otter latrines and species that use feces as food resource. Latrines were monitored with camera traps monthly in 24-hour cycles. We recorded nine species of vertebrates visiting these sites. Latrines are visited by birds, reptiles and mammals. Feeding dependency from latrines in the Atlantic Forest may not be related to less productive periods (dry season). Visitors that ate at the latrines do not have the same feeding habits as otters. The assumption that mammals would fear diseases caught in the latrines did not hold, since two mammals did not avoid ingesting feces. We speculate these two species might be less resistant or less susceptible to pathogens found in otter latrines.

Atlantic behavioral response study – Responses of Cuvier's beaked whales and short-finned pilot whales to military sonar off Cape Hatteras, North Carolina, USA

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We conducted field controlled exposure experiments (CEEs) to quantify the behavioral response of Cuvier's beaked whales and short-finned pilot whales to tactical mid-frequency (3-4 kHz - primary signal energy) active sonar (MFAS) off Cape Hatteras, North Carolina. Our objective was to provide direct empirical measurements of behavioral response in relation to key exposure variables, including received exposure level, proximity to the source, and behavioral state. We employed a multi-scale approach, with simultaneous deployment of high-resolution, short-duration, archival acoustic and movement tags and lower-resolution, longer-term, satellite-linked depth-recording tags. Unlike many previous studies, our work was not conducted on a training range, where animals are exposed to frequent bouts of intense sonar activity, but, instead, an area where MFAS is used infrequently, so that animals may be familiar with, but not habituated to sonar. We used real-time noise propagation modeling to direct source vessels, such that received levels ranged up to 130 and 150 dB re 1 mu Pa for beaked and pilot whales, respectively We validated modeled levels relative to calibrated received levels on acoustic tags and bottom-mounted acoustic recorders. During the first two years of this project, we tagged 28 Cuvier's beaked whales and 44 short-finned pilot whales. We conducted 10 controlled exposure experiments (CEEs), each with multiple tagged individuals of both species, including three trials with full-scale tactical MFAS systems from Navy ships, five trials with a high-power simulated MFAS, and two no-sonar controls. We noted behavioral response in some, but not all, individuals, including short-term changes in diving behavior and horizontal avoidance. We did not observe any large-scale abandonment of habitat in either species, and behavioral responses were generally ephemeral, with animals resuming typical diving behavior within hours of exposure to MFAS transmissions. We will conduct additional field CEEs during summer 2019.

How much is too much? A global review of thresholds of 'acceptable' impacts on marine mammal populations.

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Predicting the level of change that marine mammal populations may undergo as a result of an anthropogenic stressor is a complex task, which requires an understanding of the biological and ecological processes governing populations as well as the nature and scale of stressors. Furthermore, deciding how much change may be "acceptable" requires not only an understanding of population dynamics but also the legal framework and societal context of any particular species, population and stressor. We review the methods that have been used across the world to decide on 'acceptable' levels of population change and manage marine mammal populations under a variety of stressors, legislative frameworks and management regimes. We present a number of case studies to illustrate that the typical approaches that have been adopted fall into three categories: predictive population modelling, rule or algorithm based approaches and simple percentage based approaches. The degree of variability presented across all examples highlights that this is not a simple issue to solve – the same issue has been tackled by a variety of experts across the world and no universal solution has been found. Despite this, there is some commonality across different legislative frameworks, ecosystems and stressors in the principles applied and the factors driving decisions. The key factors influencing decisions on acceptable levels of impact are as follows: legislation, conservation status of the species or population concerned, data availability/uncertainty, stakeholder influence and the societal or economic value of the driver responsible for the change. In particular, the sustainable development of the renewable energy sector, with its importance for the mitigation of climate change and the development of a low carbon energy future provides a new context for decisions on acceptable impact in the permitting/licencing process. We present a number of guiding principles for setting thresholds of impact for such projects.

Environmental and individual influences on diving behaviour and foraging success in female Australian fur seals.

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Understanding the factors which influence foraging behaviour and success in marine mammals is crucial to predicting how their populations may respond to environmental change. While its population is still recovering from the over-exploitation of the commercial sealing era, the Australian fur seal (*Arctocephalus pusillus doriferus*, AUFS), the largest of the fur seal species, represents the greatest marine predator biomass in south-eastern Australia. The area is currently one of the fastest warming oceanic regions in the world, with anticipated changes to oceanographic conditions likely to greatly impact the distribution and abundance of prey species. Adult female AUFS forage almost exclusively on the seafloor of the shallow continental shelf of Bass Strait and are, thus, highly susceptible to fluctuations in prey availability within this restricted foraging range, with direct consequences for reproductive success. Therefore, knowledge of how environmental variables influence foraging behaviour and success in the species is crucial to predicting how its population may respond to the climate change. The present study analysed diving behaviour in 135 adult females provisioning pups during the winters of 1998-2019, covering 8.05 ± 9.10 foraging trips per individual (total 1086) and 201.5 ± 62.5 dives per individual per day (total 592,159). Successful foraging dives were identified from ascent/descent rates using previously video-validated relationships, and indices of foraging success were calculated as the proportion of successful dives and successful dives per metre of vertical distance travelled. The results revealed complex relationships in the influence of broad-scale environmental indices and individual characteristics on diving behaviour and foraging success, with inter-annual variability suggesting cycles in prey availability linked to patterns in the prevailing oceanographic currents. These findings provide insights into the potential population trajectory of the Australian fur seal population in response to the predicted changes within its broader ecosystem.

Noise drives behavioural responses of humpback whales to whale-watching boats.

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Whale-watching is a profitable business that is increasing globally. However, it can cause short-term behavioural impacts on animals with potential long-term consequences for their fitness. Despite

mounting evidence for disturbance, it remains unclear whether the sensory stimuli that trigger responses are visual or auditory. Here, we test the hypothesis that noise exposure, rather than boat proximity, is the primary driver of disturbance. To do this, we used humpback whales (*Megaptera novaeangliae*) as a model species, it being the most targeted species for whale-watching globally. We conducted controlled exposure experiments (n= 42) in a remote area serving as a humpback breeding ground in Exmouth Gulf, Australia. Controlled exposure experiments consisted of a 5m research boat passing a resting mother and calf pair at the same speed (1.5 knts) and distance from the whales (100 m) and only changing the boat noise level from a large Lubell LL-1424HP loudspeaker (control= SL 148 dB re 1 µPa @1m, medium= 160 dB re 1 µPa and high= 172 dB re 1 µPa, all rms). The behavioural responses (proportion time logging, presence of behavioural events, respiration rate) of whales were recorded 15 min *before*, *during* and *after* boat passes, using an unmanned aerial vehicle. Using mixed models, we show that compared to control noise i) the proportion of time logging for mothers decreased by ~27% during high noise, ii) mothers dove more frequently during medium and high boat noise, iii) the respiration rate of mothers increased two-fold during high noise at the same distance. We conclude that boat noise is the primary driver of short-term behavioural responses to whale-watching activities. These insights can directly inform whale-watch regulators on acceptable emission standards of boat noise to minimise negative effects on cetaceans and thereby facilitate the sustainability of the whale-watch industry.

DNA profiling by SnotBot® sampling from the spout of a whale

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Sampling the spout of a whale using an aerial drone or SnotBot®, offers a non-invasive alternative to biopsy sampling. However, most non-invasive sampling techniques provide low quantity and quality of DNA, reducing the success of a DNA profile. Here, we develop methods to extract DNA from the spout of the whale and to assess the quantity of DNA using digital droplet PCR (ddPCR). The estimated copy number of target DNA as determined by the ddPCR is compared to the 'success' of the sample as determined through conventional PCR and sequencing of the mtDNA control region. Spout samples were collected in several geographic locations from humpback and blue whales between 2016 and 2018. From 103 samples, we successfully sequenced mtDNA haplotypes from 63 samples (61%). Concentrations of DNA in 'successful' samples ranged from 0.25-100.25 copies/µl. The lowest concentration with a positive result was similar to the lower threshold for successful barcoding with environmental DNA collected from seawater in the path of whales. Success of amplification and mtDNA sequencing increased through time from 54% in 2016 to 92% in 2018. Success with amplification of other markers (e.g. sex and microsatellite loci) was more variable but also improved with time. The mtDNA haplotypes of SnotBot® samples were compared to worldwide databases and identified matches to blue whales reported in the North Pacific and humpback whales in the Gulf of Alaska and the Southern Hemisphere. In addition to confirming presence of haplotypes in sampled regions, we also identified previously unreported haplotypes. This research confirms the potential for SnotBot® samples to provide genetic information in parallel with high-resolution images for individual identification and photogrammetry. Further developments in drone piloting, with assistance from artificial intelligence, could enhance sampling opportunities, including launch and recovery from land stations or from large ships, while underway.

Indian humpback dolphin depredation in coastal purse-seine fisheries – An unrecognized problem

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Interactions with fishing gear are a known threat to cetacean populations globally, including in India. However, threat assessments in India are restricted to unravelling the bycatch problem and not depredation. Depredation, a frequently under-reported issue, has serious implications for both the fishing community and the dolphins, which could escalate to conflict over resource use in this region. To obtain a preliminary understanding of

Indian humpback dolphin (*Sousa plumbea*) depredation in coastal purse-seine fisheries, and the broader ecological and economic implications, we collected fisheries-dependent data during multiple trips and seasons aboard a fishing vessel. A binomial exact test revealed a 49% probability of depredation occurrence based on observed fishing events (n = 70), resulting in catch loss as well as costly damage to fishing gear. Approximately, 48.64% of these events involved adults with calves, suggesting social transmission of this behaviour among dolphin groups. Standard mark-recapture and foraging ecology studies may explain if the problem is more widespread in the larger dolphin population than reported here. To propose potential mitigation measures, we tested which factors of the fishing operations, including location & habitat parameters and catch characteristics, might be predictive metrics of depredation. Binomial logit-link regression showed that catch species had no measurable influence on dolphin depredation (contrary to the fishers' beliefs, assessed via interviews); total catch quantity did influence it to some extent, while water depth and distance from shore had a stronger influence—based on a sample entirely within the spatial range of humpback dolphin occurrence in our study area. While fishing crews frequently and unsuccessfully employ underwater explosives to deter depredating dolphins, the sub-lethal effects of these deterrents are unknown and require further study. Our study provides important evidence that depredation is a rising problem in coastal waters and minor modifications in fishing operations could potentially, reduce conflict.

Epidemiologic survey on the period prevalence of pinniped ocular disease and husbandry conditions within central European facilities

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A high prevalence of ocular disease from captive pinnipeds and its contributing factors from husbandry has been discussed in the past. However, there have been only a few primary studies and their data originates mainly from US-American marine parks. Therefore, an epidemiologic survey was conducted to assess pinniped morbidity as well as the husbandry of Central European facilities. The period prevalence of ocular disorders within a timespan of two years was analysed for interdependencies between management and husbandry parameters, such as (ocular) medical training, (supplemented) saltwater, water change/filtration system, ozone/chlorine disinfection and chemical/bacteriological water screenings. Twenty-five facilities from Germany, Austria and Switzerland, keeping 35 pinniped groups consisting of 209 animals, took part in the study. There was an overall period prevalence of 32 %. The data showed a difference between the period prevalence of otariids and phocids, and otariids were more often kept in disinfected water. The proportion of males was higher in groups of phocids, and there was a strong correlation between the number of male pinnipeds in a group and the number of diseased males, which was not the case amongst females. In addition, ocular trauma was only reported in phocids. A significant difference in period prevalence was found between animals kept only in fresh water and those living in saltwater or offered an additional saltwater pool. However, no difference resulting from salt concentration was detected. Within the study sample, lower period prevalence was seen in groups with medical training, filtration systems and water chlorination. In conclusion, intraspecific fighting might be the main cause of period prevalence differences between otariids and phocids and suggests that facilities should keep groups with a higher proportion of females or neuter males. In addition, saltwater, water filtration and disinfection can lower period prevalence. Frequent water screenings and daily medical training may help to prevent ocular disease.

Evaluating anthropogenic activities on humpback whales (Megaptera novaeangliae) using behavioral changes as a measure of impact: Two case studies.

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Tourism targeting marine mammals has expanded in recent years, and there is growing concern about the impacts of these activities on both the individual and population level. Here we present research examining anthropogenic activities with two types of interactions between humans and humpback whales (*Megaptera novaeangliae*): vessel interactions and swimmer interactions. For both interaction types, we observed whale behavior before, during, and after interactions to determine any significant changes. Vessel interactions were assessed in Maui, Hawaii, USA from 2016-2018, and data were collected from a land-based theodolite station to record whale responses to vessel approaches. Generalized linear models were used to determine if swim speed, dive time,

respiration rate, and directness of travel significantly differed before, during and after a vessel was present. Swimmer interactions were assessed in Hervey Bay, Queensland, Australia from 2018-2019, and behavioral observations were collected from a vessel to determine whale responses to swimmer presence. To assess impacts of swimmer interactions, changes in activity state were analyzed using Z-tests for proportions, and changes in transitions among behaviors were analyzed using Markov chain analysis. We observed significant changes in whale behavior in response to both swimmer and vessel interactions. After a vessel interaction, whales displayed significantly shorter dive times and more direct paths of travel. After a swimmer interaction, whales travelled more and rested less. If human activity causes whales to use more energy than their energy stores allow, this behavior change could, in turn, decrease the amount of energy available to feed, breed, migrate, and reproduce, which can have population-level impacts. We recommend that the behavioral changes reported here be considered in the development of regulations and management plans for each study area and highlight the need for continued monitoring of human activities on whale populations worldwide.

Of winds and ships and summer whales: Listening to climate change in the Arctic

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The effects of climate change are especially pronounced in the Arctic, where temperatures are warming twice as fast as elsewhere on the globe and sea ice decline is reshaping polar habitats. These changes have profound impacts on the physical and biological environment of the Arctic, particularly as regards the underwater environment. The acoustic ecology of Arctic marine mammals is driven by biotic and abiotic factors, each of which is changing under a warming Arctic such that we can "hear" climate change in the Arctic even during the polar night and under (increasingly reduced) ice cover. Acoustic monitoring in the Arctic is documenting changes in the atmosphere through increased ambient noise levels, changes in human usage of the Arctic via detection of shipping and oil and gas prospecting, the "invasion" of the Arctic by subarctic species, as well as changes in the phenology of Arctic marine mammals.

Prey availability vs prey abundance: Understanding the mechanisms underlying a population decline though a long-term biologging study of Antarctic fur seals.

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The use of technology has increasingly revealed the cryptic behaviours of marine mammals such that biologging studies are now commonplace. However, because of financial, ethical and logistical constraints they are usually limited in duration or sample size. Here we report on the analysis of over 1400 deployments of telemetry tags (TDR,PTT and GPS loggers) on female Antarctic fur seals breeding at South Georgia spanning 17 years. This unique dataset is complimented by an acoustic survey, targeting the seals' main prey Antarctic krill, which is run annually in the waters where they forage. These data provide us an exceptional opportunity to determine how these predators adapt their foraging behaviour in the face of temporal fluctuations in local krill abundance. Antarctic fur seals at South Georgia, representing 95% of the world population, have recently shown local declines that are thought to be linked to global climate change and reduced prey availability. We show how using at sea foraging telemetry we can infer how changes krill abundance are manifested at scales pertinent to the predators such as swarm/patch size and distribution in order to better understand the mechanisms underlying these observed population changes.

What attracts Baltic Sea grey seals to seal-safe cod-pots, how do they behave and when do they attempt to attack fish in the pots?

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Seals and coastal fishery depend on the same fish stocks in the Baltic Sea, leading to inevitable competition. Seals raid fishing gear resulting in a loss in fish catch, damaged gear, and also seals caught and drowned as by-catch. Researchers have been active in developing 'seal-safe' fishing gear (cod-pots) which will be unattractive to seals and resistant to attacks. This study investigated presence of grey seals (Halichoerus grypus) around these gears, and the attempts to take fish from them. Baited and camera-equipped cod-pots of

three designs and mesh types were set out close to a seal haul-out site east of the island of Gotland (Sweden) in the Baltic Sea, and the behaviour of visiting seals filmed with underwater cameras was observed and analyzed using a Generalized Linear Model (GLM). As well as the cod-pot characteristics, the variables used for modelling included the time of day, whether bait fish were alive or dead and the quantity of fish in each pot. Seal behaviour varied and was divided it into eleven categories. The most important cod-pot-characteristic for seal presence and 'attack behaviour' was the physical design of the cod-pot. The most attractive design had loose netting around the upper chamber, in contrast to the other two designs which had tightly stretched mesh. Neither mesh size nor material showed any correlation with seal presence or attack behaviour. It was also found that the most important overall factor for predicting attack behaviour was the time of day. The 'investigation' behaviour was most commonly observed and most attack behaviours were targeted towards moving fish and no attacks occurred on dead fish. These results could suggest that seals visit cod-pots because of curiosity and not primarily because of hunger.

New technology instantly shares sightings and protects North Atlantic right whales in real-time

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Wind farm (pre)construction is ramping up along the North American east coast. At any given time, multiple vessels off the northeast United States coast could be involved in high resolution geophysical surveys, pile-driving, and other activities producing sounds exceeding NMFS-regulated noise exposure thresholds. Such sounds can overlap the acoustic range used by the critically endangered North Atlantic right whale (NARW) for communication. Thus, federal regulators typically require 2-6 Protected Species Observers (PSOs) per vessel to watch for animals and take prescribed mitigation action when necessary (e.g. shutdown and delay of sound sources, change course, etc.). Extant technology for sharing NARW locations (e.g. NMFS SAS and WhaleAlert) facilitates broad public input, requiring vetting by authorities; sightings can take over 24 hours to propagate into the field. As creators of the software (Mysticetus) used by many PSOs, we developed a system that instantly shares NARW sightings between vessels and projects to facilitate enhanced mitigation and monitoring across a large area of activity. When a PSO on one vessel sights a NARW, it is instantly displayed on the computers of all other nearby PSOs. An alarm sounds and the location, range and bearing is highlighted on a real-time map. This system dramatically decreases latency and provides recipients of these alerts (PSOs) greater detail to inform their mitigation decisions, and provide real-time, improved protection of NARW. Improved situational awareness serves as a tool for real time adaptive mitigation, allowing optimization of industry activities while reducing environmental risks. Shared sightings are also fed into other systems (e.g. NMFS SAS and WhaleAlert), leading to better coordination among all mariners and facilitating broad, long-term data integration.

Harbour porpoise hunting from a bird's eye view.

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Studying animal behaviour is important not only for understanding the natural history and ecological impact of animals, but it is also essential for protecting animals from human influence. The harbour porpoise (Phocoena phocoena) is a small cetacean found in the coastal waters on the northern hemisphere. It is known to be vulnerable to human disturbance, but the ecology of the species is still unstudied in detail. The harbour porpoise has a high metabolic rate and need to feed almost continuously, mainly on small fish. The details of its prey capture have been studied in captivity and by acoustic tags, but few visual studies exist of harbour porpoises foraging in the wild. To better understand the feeding ecology and habitat requirements of harbour porpoises we here use visual recordings of harbour porpoise foraging events. The data was opportunistically collected by use of drones during 2015-1019 in Little Belt and Great Belt, Denmark, and used to analyze foraging behaviour and predator-prey interactions from above when wild harbour porpoises feed on both schooling and individual fish. Results from this project suggests that harbour porpoises have a number of foraging strategies they switch between. In addition, although harbour porpoises are mostly considered solitary animals, our data show potential collaboration between individuals. Our observations also confirm that harbour

porpoises spend considerable amounts of time and effort to capture their prey, which is in line with results from previous acoustic studies.

Genomic monitoring of New Zealand's Māui dolphins using ddRAD sequencing.

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The Māui dolphin (*Cephalorhynchus hectori maui*), a subspecies of New Zealand's endemic Hector's dolphin (*C. h. hectori*), is considered 'critically endangered' by the IUCN and 'nationally critical' under the New Zealand Threat Classification System. To date, genetic monitoring of Māui dolphins has relied on standard DNA profiling, including mtDNA haplotype, sex and up to 25 microsatellite loci for genotype capture-recapture estimates of abundance and linkage disequilibrium estimates of effective population size. Here we describe efforts to enhance the power of this genetic monitoring with the use of double-digest, restriction-enzyme associated DNA (ddRAD) sequencing. Libraries for ddRAD sequencing were prepared from n = 65 skin biopsy samples collected from Māui dolphins during the 2015 and 2016 field seasons and n = 20 Hector's dolphin samples by digesting total genomic DNA and subsequently size selecting for 300 - 400 bp. The indexed libraries were then pooled and sequenced on an Illumina HiSeq 3000 (150 bp, paired end) for an average of 4.1 million forward reads per sample. We used strict filtering criteria (e.g. 20x minimum initial stack depth) within the program STACKS to identify 1,591 variable loci in Māui dolphins. Using these loci we confirmed the identity of n = 48 Māui dolphins previously identified by microsatellite genotyping, and the resulting abundance estimate of $N = 62$ individuals (95% CL, 55 to 73) using a closed population model. Effective population size (N_e) was estimated to be $N_e = 54$ (95% CL, 53 to 55) using the LDNe method. Further analyses are underway to assess biases in estimates of N_e when using genomic data and to identify parent-offspring pairs for improved estimation of both census and effective population sizes. Our results provide a transition from conventional DNA profiling to genomic monitoring of this critically endangered subspecies.

First insights into the ecology of false killer whales observed in the Azores.

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False killer whales, *Pseudorca crassidens*, are infrequently observed in the Azores. Since 1987, there have been roughly 125 sightings around various islands of the Archipelago.

Photo-ID analysis of dorsal fins shows several long term (13 year) and inter-island matches (80-125nm). Given the infrequency of sightings, the fact that there are multiple re-sightings of individuals combined with individuals sighted only once, indicates that part of the population shows some degree of residency in the Azorean archipelago. Several individuals have been re-sighted together over multiple years, supporting the known cohesive social structure of this species. Group size varies from 2-150 individuals. New-born calves have been encountered on multiple occasions, indicating that the Azores may serve as a nursery ground and constitute a critical habitat for this species. False killer whales have been observed multiple times in association with bottlenose dolphins, *Tursiops truncatus*, and occasionally other species. Aggression from resident Risso's dolphins, *Grampus griseus*, towards false killer whales has been documented off Pico Island.

False killer whales in the Azores have been observed feeding on tuna, snipe fish, mullet and wreck fish and may follow food resources around the archipelago and surrounding submarine mountains. These animals may require protection, since they interact with fisheries and at present there are 2 known by-catch events in the local long-line fishery.

To date, individual matches between the Azores and the other Macaronesian Archipelagos have not been verified for this species. Since other odontocetes, such as short-finned pilot whales, *Globicephala machrorhyncus*, and sperm whales, *Physeter macrocephalus*, have shown long range movements within Macaronesia, false killer whales may also move between these archipelagos. In the

future, matching will be done between the Azores and the remaining areas of Macaronesia, to gain insight into the movement patterns and distribution of this top predator.

Population genetic structure of harbour seals in Ireland – filling a knowledge gap to evaluate and monitor Good Environmental Status

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The EU MSFD (2010/477/EU) is a key instrument for marine conservation in Europe. It establishes a framework for achieving/maintaining Good Environmental Status in the marine environment. Within this framework, Member States are to establish environmental targets and associated indicators, in addition to implementing monitoring programmes and programmes of measures for said indicators. Seals are top predators that have a crucial role in the marine ecosystem and can be used as indicators to assess its health. Currently, two seal biodiversity common indicators are being employed within OSPAR regions II and III, including an assessment of trends in seal abundance and distribution. To undertake such an assessment, delineation of biologically significant Assessment Units (AUs) is required, though no such AUs have been proposed for harbour seals in Irish waters due to a lack of genetic data and thus currently harbour seals are managed as a single nationwide population.

The present study utilises a combination of mitochondrial and nuclear genetic markers to characterise the population structure of harbour seals in Irish and adjacent waters thereby providing advice for the delineation of reproductively isolated and biologically significant AUs. Biological samples were collected non-invasively (e.g. scat, hair) from key haul-out locations (Ireland) and corroborated with samples from stranded/rehabilitated individuals (Ireland, UK, Germany). The mitochondrial control region (d-loop) and 14 nuclear loci were analysed for 240 individuals.

Analysis of mtDNA among distinct geographical areas based on the distribution of key haul-out sites identified a high haplotype diversity and indicated the presence of sub-structuring for harbour seals within Ireland as well as among adjacent waters. These findings suggest that the current management approach for Irish waters may be inappropriate. Once corroborated with nuclear genetic data, this analysis will provide crucial information for the conservation and management of the harbour seal in Irish and European waters.

How can citizen science contribute to marine mammal research? Challenges, best practices and the role of new technologies.

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Sustaining long-term ecological monitoring of marine mammals is difficult as it requires dedication of a researcher or organization, funding, and resources. Since marine mammals are charismatic megafauna and many species are observed by the public, citizen science can be an effective approach for research and conservation. Recruitment and retention of volunteers can be facilitated by working with a partner organization to manage logistics. A key measure of success from the volunteer perspective is feeling that they are actually contributing to scientific research, so it is essential to provide real opportunities for them to record data and be involved in analyses. Organization, with identified roles, clear protocols for data collection, and new technologies increase the effectiveness of volunteer contributions. Applications such as *Collector App* (Esri), can be customized with project specific fields, and drop-down menus reduce the risks of entry errors. They also allow direct upload of records into maps and databases, which reduces the time required in post-processing. The public can also contribute sightings independently with mobile apps; *Whale mAPP* is designed for users to record the location and details of sightings globally and the data is freely available. Matching photographs for identification of individuals has often relied on expert members of the research team and requires a steep learning curve, but automatic recognition software is increasing the efficiency of the process. *Wildbook* is an open-source algorithm used to match dolphin fins and can increase collaborations by identifying other researchers who have observed the same animals. Volunteer engagement after the project is best maintained via social media and frequent project updates. Successful citizen science projects can work as a true collaboration between trained scientists and the public, advancing scientific

research, while helping to break down artificial boundaries leading to a shared mission for conservation.

The 'whale trap': Will climate change benefit endangered NW Atlantic blue whales, (Balaenoptera musculus)?

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Despite protection from hunting since 1964, the Endangered northwest Atlantic blue whale population has failed to recover, with an estimated population of less than 200 mature individuals. One factor that may be having a significant impact on potential recovery is mortality of adult blue whales due to sea ice entrapments off the southwest coast of Newfoundland, Canada.

Generally, ice entrapments occur in years when extensive ice blocks the entrance to the Gulf in the spring. Due to the geography of the coastline and the presence of a coastal current, a strip of open water usually persists along the southwest coast of Newfoundland which is utilized by blue whales for feeding. The "whale trap" occurs when strong westerly winds drive ice into this open water, entrapping the whales present. Entrapments have been reported since 1868, and since 1974 41 blue whales are know to have died including nine in 2014 alone, resulting in a high level of adult morality.

There has been a significant decline in ice in the Gulf over the past two decades and the number of years with sufficient ice to entrap blue whales has declined. Climate models predict that ice extent and thickness will continue to decline in this area which may reduce the likelihood of ice-related mortality among NW Atlantic blue whales. However, the reduced ice cover is more mobile in response to wind, and strong wind events are becoming more common which could increase the speed at which these entrapments may occur. Unless this ice entrapment mortality is reduced, recovery of the NW Atlantic blue whale population will be jeopardized.

Using prey availability and environmental covariates to forecast humpback and fin whale distributions in the Northeast United States

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Predicting the distribution of large whales on the Northeast United States coast is important to mitigating the impacts of anthropogenic activities including ship strikes, entanglement in fishing gear, and offshore energy development. Direct measurements of prey availability are not typically available and thus environmental parameters are often used as proxies for prey distributions in predictive habitat models of whale distributions. To date, long-term marine mammal surveys conducted in the Northeast U.S. since 1993 and fisheries bottom trawl surveys conducted by the Northeast Fisheries Science Center since 1968 have been used independently to model single- or multi-species distributions but have not been combined to model the distribution of marine mammals as a function of prey availability. Recently developed dynamical forecasting systems provide the opportunity to predict distributions of cetaceans and their prey on subseasonal time scales (lead times of days to weeks). Our objectives were to integrate prey distributions into predictive models of fin and humpback whale distribution, and to compare the predictive capacity of these models with and without prey distributions using subseasonal (SubX) sea surface temperature forecasts. We develop generalized additive models for humpback whales and fin whales, respectively, based on both environmental covariates and predicted prey distributions and use SubX forecasts to generate probabilistic predictions of forage fish, humpback whale and fin whale distributions. We present forecasts with lead times of 5 to 30 days along with estimates of forecast skill for the northeast US. Preliminary results suggest that models integrating environmental and prey variables perform better than environmental models alone, and increase the predictive capacity of marine mammal models using forecasted products. These forecasts would provide fishermen and managers with information about times and areas where whales are likely to occur (i.e., high risk areas for ship strikes and entanglements).

Off-range Southern elephant seal (Mirounga leonina) and Antarctic fur seal (Arctocephalus gazella) stranded in the coast of Peru: A La Niña side effect?

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Off-range pinniped presence in the Eastern South Pacific coast is poorly documented. To improve our knowledge of extra-limital records found on Peru's coast, ORCA has recorded stranded specimens over the past 18 years. Here, we describe the occurrence of *Mirounga leonina* and *Arctocephalus gazella* stranded in Peru associated to cold temperature abnormality (La Nina). For every stranded pinniped, we recorded gender, biometrics, physical description, geo-location and stranding cause. Both species were identified according to their morpho-anatomy characteristics, body size, and teeth count to differentiate from similar species. All specimens monitored were found alive and returned to the ocean after stranding. ORCA Stranding Network has recorded 4 accounts of Southern elephant seals (*Mirounga leonina)* and one Antarctic fur seal (*Arctocephalus gazella)* in Peruvian beaches during the summer months (December-March) between 2016 and 2018. *A. gazella, and M. leonina have a known range surrounding the circumpolar region. M. leonina were found within the central coast of Peru and appeared having ailments;* a malnourished adult female *A. gazella* was recorded on RegatasSur beach in Lima, Peru, on December 28th, 2018, being the most recent and northern record for the species. These off-range pinnipeds were found within cold water temperatures ranging from 17°-21° degrees Celsius, indicating the presence of a cold water stream running along the coast of Peru at the time of the strandings, where regular SST is warmer for that time of the year (+2°/+4°C). *There are previous reports of these pinnipeds found in both Chile and Ecuador associated to cold temperature abnormalities as well.* Sightings of *A. gazella* and re-occurring sightings of *M. leonina* highlight the importance of Peru's ecosystem as resting site for these traveling pinnipeds. ORCA's observations of these stranded pinnipeds are significant to understand how the ocean is rapidly changing and potentially affecting the distribution of these species.

Per and polyfluorinated alkyl substances (PFAS) in coastal and estuarine Indo-Pacific bottlenose dolphins (Tursiops aduncus), Western Australia (WA)

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PFAS have drawn increased focus in the past decade due to their persistence, bioaccumulation, biomagnification and global distribution. Synthetic compounds with surfactant and repellant properties, they have been used since the 1960s in numerous industrial and household substances. Perfluorooctansulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexanesulfonate (PFHxS) are most commonly found. Due to global detection, the main producer phased out production of perfluorooctanesulfonyl fluoride (POSF), the major PFAS precursor, in 2000. In 2009, PFOS was added to Annex B of the Stockholm Convention, restricting its use; PFOA is proposed for listing. In Australia, PFAS (predominantly PFOS) was used at airports and military airbases in fire-fighting foams, contaminating several locations; consequently PFOS-containing foams have been largely phased out. PFAS coatings (predominantly PFOA) on fabrics and metal surfaces are also, to a lesser extent, responsible for environmental contamination in Australia. The highest concentrations of PFAS are measured in piscivorous apex predators such as marine mammals. We analysed liver samples from deceased *Tursiops aduncus* from three coastal and estuarine locations in WA; given their inshore distribution and site fidelity, *T. aduncus* are excellent biological sentinels, potentially facing increased risk from terrestrial pollution. Samples were selected based on proximity to industrialisation using stranding location and/or life history; we contextualised our findings with those reported both nationally and globally. The Swan River dolphins (Perth, WA) exhibited significantly higher concentrations than the other two WA locations, as well as elsewhere in Australia; comparison with the international literature found their hepatic PFOS concentrations to be amongst the highest reported in marine mammals globally. Whilst this is a preliminary PFAS exposure survey, assessing exposure helps understand potential sources. Evaluating the magnitude of exposure in resident sentinel dolphin populations is of interest from a conservation and public health perspective; given some PFAS are endocrine

disruptors, tumour promoters and immunosuppressors.

Using UAVs for morphometric measurements of harbour porpoises (Phocoena phocoena).
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An animal's body condition directly influences its survival and reproductive fitness, and therefore also the health of the populations. Monitoring cetaceans' morphometric measurements are usually obtained from stranded or bycaught individuals. This may bias interpretations on age - and sex-related growth as well as the status of their populations. The purpose of this study was to determine morphometric measurements of harbour porpoises *(Phocoena phocoena)* by using overhead video recordings from commercial UAVs (Unmanned Aerial Vehicles). From a customised program that implements the UAV parameters (height, gimbal orientation, camera parameters and Field of View), we were able to obtain the length and girth of 7 individual harbour porpoises of known sizes, very similar to the actual measurements and with a maximum error of 7.4%. Using length and girth, enabled determination of a body condition score (BMI Index) for each animal with an overall average error of 0.8 points. The method was then applied on recordings of free-ranging harbour porpoises with calves to determine the body condition. Furthermore the length was used to predict an approximate age, that all corresponded with the calves being born during spring. This is a very cost-effective monitoring method and a valuable complement to the current body assessment methods from bycaught or stranded animals that can aid in monitoring the growth and health of calves and adults on population scales throughout various seasons.

A multi-method approach to evaluating patterns and variability in the diet of Baffin Bay polar bears.
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Climate warming in Arctic ecosystems is having pronounced effects on top predators. The loss of sea ice affects polar bears (*Ursus maritimus*) by reducing access to ice-associated prey. Detailed studies of polar bear foraging are necessary for understanding how diet may shift over time. Use of multiple chemical tracers may provide dietary insights in the context of habitat use, as each tissue formation timeline may reveal temporal differences in diet and habitat. We elucidate the feeding habits of the Baffin Bay polar bear subpopulation through use of hair stable isotopes, hair mercury concentrations, and adipose tissue fatty acids. We collected 138 hair and fat samples from Baffin Bay polar bears captured in connection with satellite tagging operations in spring of 2009-2013. Hair samples were analyzed for carbon, nitrogen, and sulfur stable isotopes and total mercury concentrations while fatty acid signatures were extracted from adipose tissue biopsies. Together, these data were used to evaluate feeding strategies of different ages and sexes and to compare differences in diet between habitat types. Baffin Bay is an area of seasonal sea ice and bears have demonstrated differences in habitat use throughout the year. Most bears move across the pack ice to Baffin Island and fast on land over the summer ('pack ice bears') whereas others remain resident at glacier fronts in NW Greenland ('glacier bears'). A lack of significant differences between hair $\delta^{15}N$, $\delta^{13}C$ or $\delta^{34}S$ ratios and THg concentrations for glacier vs. pack ice bears suggested similarities in trophic position and feeding. Nonetheless, significant differences in dietary fatty acid signatures between the two groups indicated some differences in prey composition exist, perhaps during certain times of the year. This suggests multiple methods should be incorporated in polar bear feeding studies to detect how diet varies with changing sea ice availability in the Arctic.

The effectiveness and influence of training on marine mammal data collection within Ghanaian waters
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Tullow Ghana Limited (TGL) have been gathering marine mammal and turtle sightings surrounding the Jubilee oil field and Tweneboa-Enyenra-Ntomme (TEN) fields, off the coast of Ghana for 8 years. A total of 1200 marine animal sightings have been recorded over these 8 years. Between 1-Jan-18 and 31-Dec-18, 51 sightings of whales, dolphins and turtle species were recorded. Opportunistic sightings data was gathered onboard by TGL personnel monitoring and recording the presence and absence of marine animals along with some behaviour description. Since August 2013, Gardline has provided marine animal identification and mitigation training to TGL personnel by experienced marine biologists, to increase the sightings accuracy and reduce anthropogenic impacts such as noise. After the training there has been an increase in both sightings and good quality photographs, as well as an improvement in accurate species description, resulting in 15 species of cetaceans definitively identified; including the first sightings of Risso dolphin (*Grampus* griseus) and Sperm whales (*Physeter macrocephalus*) in Ghanaian waters. In 2018, there was a great reduction of personnel that attended the training by Gardline onboard the vessels along with reduction in the number of vessels monitoring, contributing to the lowest number of sightings and several sightings being downgraded onshore by experienced Gardline staff (i.e. Definitive ID to probable). However, 8 years of continuous sightings has resulted in the largest dataset of marine mammal sightings for Ghanian waters. Respectively showing the effectiveness and influence of training to continue monitoring, the lack of knowledge concerning marine animals within Ghanaian waters and the importance of continuing this standard monitoring.

Noise and cognition in dolphins: A deeper look into anthropogenic effects on marine mammals.

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Human generated noise pollution is an increasing threat to marine mammals, yet the extent of anthropogenic sound pollution's effects on cognition are poorly understood. Dolphins use cognitive skills to hunt, maintain social groups and communicate. For our study, we measured attention in bottlenose dolphins, *Tursiops truncatus*, during acoustic playback sessions at multiple human-care facilities, both inland (where the animals experience no boat or SONAR sounds), and coastal (where the animals experience regular anthropogenic noise from cruise ships and personal water crafts). During playback sessions, the duration of dolphin look responses to control, cruise ship, jet ski and SONAR noises projected out of an underwater speaker were taken as a dependent measurement. The results were compared between facility types as well as across individual, sex and noise-type. We propose a re-evaluation of expectations around which noises are acceptable when managing wild marine mammal populations as well as discuss broader implications for expectations related to habituation and sensitization in cetaceans.

Subcutaneous encapsulated fat necrosis and loose cavitary fat bodies in bowhead whales (Balaena mysticetus) from Alaska

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The bowhead whale is, an ice-associated large baleen whale central to Inuit subsistence culture. Since 1977, aboriginal harvest of bowhead whales from the Beaufort-Chukchi-Bering (BCB) bowhead whale population is regulated under the authority of the International Whaling Commission (IWC). To date, few disease conditions have been described in bowhead whales despite their extreme longevity. We describe a case series of subcutaneous encapsulated fat necrosis and loose cavitary fat bodies in six bowhead whales harvested (2011 to 2015) North Slope, Alaska, USA. Sex and age class distribution was three immature females, two immature and one mature male with a mean (SD) total body length of 11.6 (2.4). Grossly, the firm elliptoid to round masses ranged in size from six to 15 cm in diameter and weighed between 25g to 1490g. They were beige to grey, firm and with a smooth-surface. On cut surface, subcutaneous masses had multiple irregular concentric layers with either discolored fatty tissue and calcifications. In 2/3 (66%) peritoneal encapsulated masses, adipose was yellow with surrounding layers of fibrous connective tissue. Pleural encapsulated masses (pendulant and loose) were characterized by thick fibrotic capsules, and a white caseated dry core.

The gross and microanatomical appearance of both lesion types in bowhead whales is similar to subcutaneous encapsulated fat necrosis (syn. nodular-cystic fat necrosis, mobile encapsulated lipoma, or posttraumatic fat necrosis; abacus tumor; mobile encapsulated adipose tissue) and loose peritoneal bodies, benign adipose lesions that have been described in humans and cows. The described condition is rare with only 6/121 (5%) observed from 2011-2015. The exact mechanisms of development of these encapsulated peritoneal and subcutaneous bodies in bowhead whales remains to be determined. Assessment of further cases in bowhead whales and other baleen whales is warranted to better understand their pathogenesis.

Mind the gap: A striking absence of welfare science in marine mammal conservation.

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Human activities influence not only the survival and fitness of populations but also the welfare of individuals. However, conservation biology and animal welfare science are often viewed as widely disparate scientific disciplines. Nonetheless, welfare science can inform conservation and there is growing recognition of how these disciplines can be united to significantly improve conservation outcomes. To determine how this critical nexus is reflected in the study of marine mammals, we examined the peer-reviewed literature. Since their 1972 and 1985 instigation, Aquatic Mammals and Marine Mammal Science have (up to Mar 2019) published a total of 1,202 and 2,349 peer-reviewed articles, respectively. However, of these only 3.5% (n=42) and 0.5% (n=11) respectively, feature 'welfare' either in the title, abstract or keywords. When expanding the same search to all English written peer-reviewed journal articles detailing any marine mammal taxa from 1972 to 2019 (n=8,998), the proportion of those articles detailing 'welfare' still only equated to 2.8% (n=255). The terms 'stress' and 'cortisol' (levels and/or concentrations) are often used by authors to infer welfare measures and/or impacts. However, both terms also reflected poorly in the broader scientific literature, accounting for just 5.7% (n=517) and 2.4% (n=212), respectively across all papers surveyed concerning marine mammals. Of these,1.0% (n=12) and 0.6% (n=7) featured in Aquatic Mammals and 0.6% (n=14) and 0.5% (n=12) featured in Marine Mammal Science, respectively. Based on these results, we propose that the benefits to be gained from increased integration of welfare science, including individual health studies, into conservation management efforts may not be fully recognised and/or utilised presently. We make recommendations to help address this apparent deficit, including a call for conservation biologists and marine mammal heath specialists to actively seek synergies in their work via the emerging discipline of conservation-welfare.

The origin and spread of distemper virus in phocids

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Morbillivirus infections constitute an increasing and pressing problem to marine mammal populations worldwide. For instance, the Canine Distemper Virus (CDV) and Phocine Distemper Virus (PDV) have caused major mass mortalities in a range of Arctic, Antarctic and temperate phocid seals. However, little is known about the origin of distemper and the drivers spreading the viruses among phocid species and populations, as well as transmissions to and from terrestrial carnivores. Here we investigate the evolution and divergence of PDV and CDV by Bayesian phylogenetic analyses of 1,698 bp of the H gene from a total of 125 samples, as well as more than 6000 bp of the PDV and CDV genome in a smaller sample of 94 animals. The phylogenetic analysis supports the existence of several CDV and PDV clades, and several transmission events between phocid seals and terrestrial carnivores. Intriguingly, our results suggest that the CDV strains causing outbreaks in Baikal and Caspian seals are the CDV strains most closely related to PDV. Furthermore, it seems that PDV and CDV diverged as recent as in the late 17th century, possibly coinciding with increases in transmission rates among e.g. domestic dogs and phocid seals associated with Eurasian trade and colonialism.

How do marine mammals maintain blood flow while diving?

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Marine mammals are known to constrict their blood vessels while diving, but it is unclear how their hearts compensate for the increased resistance to blood flow. We answered this question by comparing the anatomy and electrical activity of marine and terrestrial mammal hearts. We performed echocardiography on 8 Steller sea lions (SSLs) and electrocardiography (ECGs) on 8 SSLs, 5 northern fur seals (NFSs), and 1 walrus under anaesthesia—and compared ECG parameters of 17 species of marine mammals to 50 species of terrestrial mammals. The echocardiograms showed that SSLs have larger aortic roots, likely acting to decrease cardiac work. The SSLs also had relatively larger left ventricular end-systolic dimensions, meaning that the left ventricle contracts less than in similarly-sized terrestrial mammals. Characteristics of SSL, NFS, and walrus ECGs varied between species and among individuals. Sinus arrhythmia (heart rate variation) is thought to be associated with diving ability and was recorded in 5 of the 8 SSLs, but not in the NFSs or walrus. Unlike terrestrial mammals, the greatest electrical activity in 5 SSL and 2 NFS hearts was not in the left ventricle, suggesting that it is not their most muscular cardiac chamber. Our interspecific comparison of ECGs further revealed that marine mammals had 20% longer P-waves and 11% longer QRS intervals than terrestrial mammals, but that the duration of the overall cardiac cycle was the same between marine and terrestrial mammals. In other words, marine mammals had slower atrial and ventricular depolarization than terrestrial mammals, but similar heart rates. Overall, it appears that marine mammals can maintain blood flow while diving because they have larger aortic roots than terrestrial mammals. Differences in electrical activity and left ventricular end-systolic dimensions may also contribute to overcoming vascular resistance when heart rate is reduced.

Evidence of group density effect on behavioural differences in grey seal (Halichoerus grypus) neonates during lactation period.

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The abundance of grey seals (*Halichoerus grypus*) in Atlantic and Baltic waters has been increasing in recent years. It is important to understand factors affecting this growth and how the growing population can influence the behaviour of individual seals. Individual behaviour during the lactation period is important for later development in many mammals and the social environment in which an individual is raised can influence their adult behaviour in the future. To broaden the understanding of how different social surroundings can influence grey seal neonate behaviour, 16 wild pups were observed during the suckling period of 2017 on the Isle of May, Scotland. Different social and non-social behavioural states and distances from mothers were recorded at 5 minute intervals for several hours during daytime. Locations of the mother and pup and all surrounding individuals were marked and maps visualizing daily individual locations within the breeding site were created. Nonparametric statistical analysis of the collected data showed that group density had a significant effect on the frequency of ALERT behaviour (Kruskal Wallis test, $\chi 2(2) = 14{,}774$, $p = 0{,}001$). Pups in densely aggregated areas expressed ALERT behaviour more often than pups in sparsely aggregated areas (Dunn's test with Bonferoni adjustment, $Z = 29{,}718$, $p = 0{,}001$). This difference was especially significant in male pups (Dunn's test with Bonferoni adjustment, $Z = 16{,}703$, $p = 0{,}014$). According to earlier studies of consistent individual differences in adult grey seals, differences in the tendency to perform vigilance behaviours such as ALERT comprises a key behavioural component that distinguishes behavioural types. The current study provides evidence of possible early development of this individuality during the suckling period, influenced by different group densities of the surrounding colony.

Heteroplasmy; Detection, verification and recurrence in baleen whales.

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Heteroplasmy is defined as the presence of two or more different mitochondrial DNA (mtDNA) genomes in one individual. Heteroplasmy can arise from insertions or deletions (length heteroplasmy) or single nucleotide substitutions (point heteroplasmy). The phenomenon has been widely studied in humans and model species; however, reports from non-model species are rare, possibly because heteroplasmy was undetected or ignored during sequencing. Among cetaceans, a few studies have reported heteroplasmy and speculated on its possible effects, suggesting that heteroplasmy could be rare or simply ignored. The aim of the present study was to assess and confirm point heteroplasmies, as well as to determine their frequency in five baleen whale species. We analyzed 10,748 mtDNA sequence electropherograms of the mitochondrial control region obtained by Sanger sequencing. A pipeline was developed to detect potential heteroplasmy by analyzing chromatogram peak heights. Potential heteroplasmies were subsequently verified experimentally. A total of 7,882 samples were assessed, among which 326 (4,1%) presented potential point heteroplasmy at more than 35 different nucleotide positions. These results indicated that heteroplasmy is more frequent than previously reported. Several heteroplasmies were tracked across multiple generations, providing insights into the introduction of new mtDNA haplotypes. Ignoring heteroplasmy might bias relatedness analyses as well as estimates of genetic diversity and mtDNA mutation rates. Thus, it is extremely important to develop efficient ways to detect and verify heteroplasmy.

Heavy metal concentrations in Tursiops truncatus off central coast of Veracruz, México.

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The National Park "Sistema Arrecifal Veracruzano" (Veracruz Reef System, VRS), located in the middle of the Gulf of Mexico, is a Federal Natural Protected Area with biological, economic and social importance, and where different ecological interactions occur. It is also the location of one of the most important urban development activities in the country: the Veracruz Port expansion. For this reason, it is of utter importance to develop in-depth research using bio-indicator organisms such as dolphins, which reflect the impacts of human activities on marine ecosystems. Besides collecting data on dolphin density, behavior and photo-identification, we analyzed heavy metal concentrations in the blubber of *Tursiops truncatus*. From June 2016 to July 2017 systematic boat-based navigations were conducted and five blubber samples were collected using a crossbow and modified arrows. Concentrations of six metals (Pb, Cr, Fe, Ni, Cu, Zn) were estimated using the total reflection X-Ray fluorescence spectroscopy (TXRF) technique. Mean and standard error concentrations were as follows: Pb 2.5±1.0µg/g; Cr 32.6±6.9µg/g; Fe 404±76.9µg/g; Ni 19.5±6.1µg/g; Cu 44.4±20.2µg/g; Zn 357.3±118.9µg/g. Our results show that our values are above what was reported in other studies around the world, except for Zinc. This suggests an extended exposition to pollution sources from human activities. This study constitutes the first step within a long-term health monitoring program in the VRS, and we plan to expand our assessment to potential dolphins' preys and seawater. Our ultimate goal is to provide relevant scientific information for environmental stakeholders in order to promote marine ecosystem conservation.

Population size and IUCN Red Listing of a threatened franciscana population

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The franciscana (*Pontoporia blainvillei*) is endemic of coastal waters from Brazil (18º25'S) to Argentina (42º10'S). The species is regarded as the most threatened small cetacean in the western South Atlantic Ocean due to high bycatch levels and habitat degradation. The franciscana is listed as Vulnerable in the IUCN Red List of Threatened Species. Recent analysis of mtDNA suggested that individuals found in the species' northern range (Brazilian State of Espírito Santo, ES) represent an isolated population. Three aerial surveys (December-January/2011, March/2018 and January-February/2019) following design-based line transect methods were conducted to assess distribution and estimate abundance of franciscanas off ES. A total of 324 transects were surveyed from the shore up to the 30m isobath between Itaúnas (18º25'S) and Presidente Kennedy (21º17'S), north and south ES boundaries. A total of 40 franciscana groups were seen (on-effort=27, average group size=2.5, SE=1.1) in coastal habitats (average distance from the shore=3.3km, SE=2.3km, range=0.4-8km). Abundance corrected for visibility and group size biases was estimated at 922 individuals (CV=0.35, 95% CI=470-1,810) combining data from 2018 and 2019. Results suggest that, at least during the summer, franciscanas in ES are distributed in very coastal habitats between Conceição da Barra (18º35'S) and Santa Cruz (19º56'S), within an area of only 2,400km^2. This is probably the smallest and the one presenting the most restricted range among all franciscana populations. The estimated abundance indicate that the ES population qualifies for listing as "Endangered" under the IUCN Red List criterion C2a(ii) because of the small size (less than 2,500 mature individuals) and because of an inferred decline in abundance as a consequence of bycatch and habitat degradation. Further research is needed to assess current mortality levels and to identify areas where conservation actions (e.g., establishment of no-take zones) can be implemented to minimize the extinction risk of this population.

Assessment of distribution and relative abundance of Guiana dolphins (Sotalia

guianensis) and common bottlenose dolphins (Tursiops truncatus) in an area severely impacted by an iron mining dam collapse in Brazil

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Guiana dolphins (GD) and common bottlenose dolphins (BD) occur along the coast of the Espírito Santo State (ES), southeastern Brazil, however information on their distribution patterns and abundance is scarce. In November 2015, after the Fundão iron mining dam collapse, the ES coastal area was impacted by the discharge of 39 million m^3 of toxic mud. Understanding the ecology of an impacted population is key to assess impact magnitude and to design monitoring plans. Here we present data about distribution and relative abundance of both species off the ES coast. Between January-February 2019, aerial surveys were carried out from Vitória (20°17'S/40°17'W) to Itaúnas (18°25'S/30°42'W). Design-based line transects (n=88, maximum transect length=20km) were placed perpendicular to the coast up to the 30m isobath. All groups of GD and BD were georeferenced and the relative abundance was estimated. A total of 59 groups of GD (mean group size=4.6; SD=7.4; range=1─50) and 17 of BD (mean group size=9; SD=18.6; range=1─80) were sighted throughout the survey area. GD groups were sighted from the coast up to the 30m isobath, with the highest encounter rate (ER) between 0-10m (7.2groups/100km). BD groups were sighted from 10m to 30m of depth, with the highest ER between 20-25m (2.3groups/100km). Relative abundance (uncorrected for visibility and group size biases) was estimated at 505 individuals (95%CI 282─906; Density=0.54; CV=0.30) of GD and 950 individuals (95%CI 280─3,221; Density=0.28; CV=0.66) of BD. The sediment plume discharged into the ocean showed a highly overlap with the distribution of GD and BD reported here, thus suggesting that these populations may have been directly impacted by the sediments. Although these are preliminary data on distribution and abundance of these species after the disaster, the results presented here can be used as a baseline to monitor long-term impacts of the mining dam disaster on these species.

Novel balloon census method for fusion of acoustic and visual census for the Ganges river dolphins ((Platanista gangetica)

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A balloon census with the multiple compact video camera system (GoPro HERO) was developed and improved for supporting the fusion census of acoustic and visual census of the Ganges river dolphins to compensate the drawbacks of the visual census and increase the accuracy of the quantitative census data analysis and individual dolphin's information. In order to increase the surfacing dolphin's detection probability by the balloon camera system similar to that of a human observer, a visual field distance greater than 80m ahead of the census boat should be captured by the camera system with sufficient resolution. Therefore, we introduced a forward-looking compact video camera system with appropriate tilt angle along with the existing downward-looking video camera system. In addition, to maintain the visual field of the camera system for the field test in the river system, pitch angle of the both video camera systems can be tracked and controlled by the gyro sensors and via the software installed into a PC/tablet/smart phone through WiFi. Fusion census of both acoustic and visual census with the improved camera system on the balloon was conducted at the same experiment site in the Ganges river system for several days in February 2018 and 2019. The performance of the balloon camera system for supporting the fusion census was demonstrated well, even though the balloon census could be conducted only when the wind direction was aligned with the boat cruise direction. The balloon camera system could capture the individual dolphin's features such as migration behavior of the dolphin with a calf and the body length measurement of the small calf, and so on which will help the river dolphin's behavioral study.

Why Baja? An empirical model for estimating field metabolic rates and thermoregulatory costs

of gray whale calves (Eschrichtius robustus).
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The purpose of this study is to develop a conceptual basis for comparing gray whale calf field metabolic rates to estimates of body heat losses and consequent required thermogenesis for body temperature maintenance from birth to weaning. The unavoidable minimum rate of body heat leakage is assessed and compared to the calves' metabolic activities.

I describe patterns and magnitudes of several morphometric, ventilatory and thermoregulatory characteristics of young gray whale calves, both free-ranging and captive, to quantify the metabolic activities and consequent energy requirements of individual gray whales in field situations.

Empirically derived equations (most scaled to body length) of four morphometric, seven ventilatory and nine thermoregulatory characteristics are developed to provide estimates of field metabolic rates and thermoregulatory costs to improve our understanding of the energetic demands that gray whale calves make on their lactating mothers, particularly in the face of disturbances that interfere with efficient and successful foraging. Where available, literature-reported CV values are assigned to random-normal functions to estimate variability of each derived equation.

Between birth and weaning, typical gray whale calves grow about 3m in length and increase body mass about 5x. Mean daily field metabolic rates (FMR) increase from 138 Mj at birth (2.4•BMR) to 264 Mj (1.5•BMR) at weaning.

Body surface and ventilatory heat fluxes were evaluated separately , then combined to estimate minimum total heat losses from birth to weaning at three ambient water temperature regimes; 18°C typical of winter natal lagoons, 2°C, typical of summer arctic conditions, and an intermediate value of 10°C typical of Oregon coastal waters during summer.

Comparisons between estimated minimum rates of heat loss and MR shown in Fig. 12 indicate that, for neonates, their required thermogenesis in 18°C winter lagoon water is substantially less than their estimated mean MR, and that no additional thermogenic activity over mean MR is required to maintain normal body temperature.

By the age of natal lagoon departure, calves in good body condition are capable of tolerating heat losses experienced in 2° C water without additional thermogenetic activities. It follows that little thermogenic advantage is achieved even by small calves by remaining in warmer waters along the migratory route during summer rather than returning to the Bering or Chukchi Seas.

Working with the lobster fishery to develop conservation measures for North Atlantic right whales in the Gulf of Maine, USA
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The population of endangered North Atlantic right whales, *Eubalaena glacialis*, has been in decline since 2010, with mortalities outpacing a declining birth rate and increasing calving intervals. Most of these mortalities are related to anthropogenic causes, namely entanglement in fixed fishing gear. New regulatory measures to reduce the rate of serious injuries and mortalities due to entanglements, specifically in the American Lobster fishery, have been initiated in the US. However, there are information gaps regarding how the vertical lines of fixed gear are fished throughout the Gulf of Maine where the majority of this fishery exists. Additionally, little data exist on the functional needs of this industry for vertical line hauling strength spatially. We formed a collaborative with states, industry associations, and researchers to collect data on vertical line fishing practices in the region through an extensive outreach program. The program included a gear survey that resulted in 867 responses from fishermen on how and where they fish, 215 breaking strength tests of donated vertical lines, and documented hauling loads experienced by eleven fishermen fishing between 5-35 pot trawls in up to 400-meter depths throughout the region. These data are being used to build a model for use by managers to both describe the landscape of vertical line use and needs in the region, as well as assess proposed regulatory measures for conservation benefit to right whales and the impact of such measures on the fishing industry. We will present the outcomes of the outreach and research program, in addition to discussing how the collaborative worked within the regulated fishing

community to develop measures to protect North Atlantic right whales.

Changes in saliva steroid hormone levels of grey seal pups during lactation and post-weaning fast.

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Steroid hormones play a crucial role in modulating social and sexual behaviour of mammals. Steroid hormones affect and organize brain areas during early development leading to a future sex based behavioural differences. Disruptions in steroid hormone production and metabolism during critical early development stages might lead to certain behavioural failures in the future. Grey seals are large marine mammals, top predators and capital breeders. To understand how steroid hormones are likely to vary naturally in young grey seals, we collected saliva samples from grey seal pups during lactation period and post-weaning fast (up to 38 d postpartum) in 2012 and 2017 at the Isle of May (UK) breeding colony. Saliva was chosen for steroid estimation, since it measures unbound steroids that are considered to act directly on target cells. Synthetic swabs (Salimetrics) were used for obtaining saliva samples. Estradiol (E, N=57), testosterone (T, N=60) and cortisol (C, N=64) concentrations were measured with ELISA kits (IBL-International). Z-score normalization was applied to measures to avoid any differences in absolute concentration levels between years. No difference in E, T and C steroid concentration was found between sexes of grey seal pups (Mann-Whitney, $p > 0.05$). E and C levels reduced with pup`s age (Spearman's rho, E: $R = -0.489$, $p < 0.001$; C: $R = -0.339$, $p = 0.006$), while T levels did not change significantly with age. Means of concentrations of all steroids were 34.76% (E), 29.95% (T) and 42.09% (C) higher during lactation period then during post-weaning fast (Mann-Whitney, E: $p < 0.001$; C: $p = 0.001$; T: $p = 0.12$). However, highest steroid concentrations could be visible during mid and late lactation periods, and lowest - at the end of the postweaning fast (Kruskal-Wallis, E: $p < 0.01$; C: $p < 0.01$, T: $p = 0.27$).

Going with the flow or against the tide: Inspiring Marine Mammal Research and Conservation in Indian waters.

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Dipani will offer stories and anecdotes from marine mammal researchers and conservationists in India. A young community and an upcoming field she tells how they tackle bureaucracy, logistics, lack of funding and lack of political will. Built on the concept of knowledge building and action research - Dipani offers a glimpse into the essence of marine mammal science and conservation in India.

Core intestinal microbiota of captive bottlenose dolphins at three aquaria

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The intestinal microbiota is formed by the enormous number of bacteria and underpins the health and homeostasis of the host. Of these bacteria, core microbiota in the intestine is suggested to have co-evolved with the hosts and perform significant functional roles. We previously revealed that the differences of the composition of intestinal microbiota in captive bottlenose dolphins *Tursiops truncatus* at three aquaria, however, knowledge of core microbiota in the species have not been investigated. Here we represent core microbiota in the intestine of captive bottlenose dolphins. Fecal samples were collected from a total of 16 captive common bottlenose dolphins housed at Ocean Expo Park (Okinawa, Japan, $n = 4$), Enoshima Aquarium (Kanagawa, Japan, $n = 7$), and Tsukumi Dolphin Island (Oita, Japan, $n = 5$). All sampling was conducted as routine health check procedures. After extraction of bacterial DNA, the V3-V4 region of bacterial 16S rRNA was amplified. All resultant amplicons were subjected to pair-end sequencing protocol on Illumina Miseq platform. To identify the core taxa, the following criteria, a) present in all individuals at each aquarium and b) present at $\geq 0.1\%$ of total reads, were used. Total 10 bacterial phyla were detected from fecal samples of dolphins at three aquaria with Fusobacteria, Firmicutes, and Proteobacteria being the predominant phyla, and these three phyla were suggested as core phyla in dolphins. Total 470 bacterial genera were detected from fecal of dolphins, and 12 genera were identified as forming the core microbiota in captive dolphins. Of these core genera, *Enterococcus* and *Lactobacillus* were

regarded as probiotics in many animals. *Cetobacterium* was suggested as common members of intestinal microbiota in freshwater fishes and produce vitamin B_{12} at high efficiency. In this study, we revealed the main target bacteria to isolate and test their benefits to maintain health management of captive dolphins.

Tracing life history of immature Antarctic minke whales: Stable isotope oscillation in baleen revealed ontogenetic diet shifts and seasonal migration.

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Understanding seasonal migration patterns in marine top predators are important to figure out how these predators affect each ecosystem. In Antarctic minke whales (AMW), *Balaenoptera bonaerensis*, winter breeding in warm ocean at lower latitude and summer feeding in cold and highly productive ocean at higher latitude are known for the mature individuals, however, migration patterns for immature individuals are unknown. Stable isotope analysis on carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) has been applied to clarify where and what immature individuals fed to estimate their seasonal migration pattern. Baleen plates of seventeen immature whales, which were obtained by whales taken in the NEWREP-A: New Scientific Whale Research Program in the Antarctic Ocean during Austral summer from 2015 to 2017, were used in this study. Variations in isotopic values in $\delta^{15}N$ determined three types of age classifications; A) newborn, B) yearling, C) more than two years old. Constant values in $\delta^{15}N$ suggested the effect from lactation in Type A (with notch) and B (without notch), while periodic cycle in $\delta^{13}C$ and $\delta^{15}N$ indicated feeding mainly on Antarctic krill in the Antarctic Ocean and migration to lower latitude as same as mature individuals in type C. These results suggested that lactation timing is clear, and immature individuals have seasonal migration as same as mature individuals.

Antioxidant properties of dolphin serum albumin

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[Purpose] Serum albumin (SA) is the most abundant protein in the blood. It functions as a carrier protein, contributes to osmoregulation, and acts as an antioxidant. Generally, SA exerts the antioxidative activity by scavenging reactive oxygen species. As marine mammals are superior divers, they are intermittently facing oxidative stress induced by reperfusion to ischemic tissues after dive. Previous studies reported on several antioxidants in marine mammals; however, no study focused on SA. We tried to reveal the antioxidative effects of dolphin SA by comparing those of other mammals' SA. [Methods] (1) The primary structures of SA proteins in cetaceans were characterized by multiple sequence alignment with other mammals sequences. (2) The degree of degradation of SA by hydrogen peroxide was tested by using SAs purified from sera in common bottlenose dolphin and other mammals. (3) The antioxidant effects of the SAs were examined by using dihydrorhodamine-123 (DHR) as the indicator. [Results] (1) The multiple sequence alignment revealed that several critical amino acids responsible for antioxidative functions were replaced to other amino acids in cetacean lineages. (2) Dolphin SA was degraded by hydrogen peroxide more than other mammals' SAs. (3) The antioxidative activity test with DHR suggested that dolphins SA may be relatively ineffective as antioxidant when compared to other mammals' SAs. These results suggest that dolphin SA may be less able in scavenging reactive oxygen species, even though cetaceans should cope with oxidative stress associated with dive.

Marine megafauna catch in Thai small-scale fisheries

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Catch in small-scale fisheries is a conservation threat to marine megafauna. Yet, it is incognisant, poorly assessed and under-monitored in Thailand, where megafauna are common and small-scale fisheries abundant. This study represents the first catch assessment of five marine megafauna groups (rays, sharks, sea turtles, cetaceans and dugong) in Thai small-scale fisheries. Data on catch and fisheries effort across one year (2016 – 2017) were collected during questionnaire-based interviews with 535 fishermen in 17 provinces along the Gulf of Thailand and the Andaman Sea during September to December 2017. Catch per unit effort estimates were generated for each megafauna group by fishing gear type. Total catch per year for small-scale fisheries of each megafauna group was extrapolated using Thai official fisheries statistics. The results showed that the annual estimated catch was 4.02 million rays, 207,920 sharks, 1311 sea turtles, 652 cetaceans and 120 dugongs in Thai small-scale fisheries in 2016 – 2017. Crab gillnets was the biggest contributor to all marine megafauna catch with a high proportion of ray (49%), shark (32%), sea turtle (78%), cetacean (62%) and dugong (94%) catch. The total catches are considered underestimates as they were extrapolated based on fishing effort from 17 provinces representing 70% of the entire small-scale fisheries effort in Thai waters. Furthermore, a number of fishing gears reported by fishermen were excluded from the extrapolation since they did not occur in the official fisheries statistics. The results highlight the need for comprehensive assessment of marine megafauna catch in Thai small-scale fisheries to allow impact assessment of catch on respective marine megafauna species.

The power of passive acoustic monitoring – a powerful tool for detecting trends in harbour porpoise densities

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The harbour porpoise (*Phocoena phocoena*) is strictly protected in the European Union and monitoring programmes that enable evaluation of trends in density or abundance are mandatory. Visual ship or aerial surveys are expensive and statistical variation is often high. Porpoise echolocation signals are an alternative measure of animal density which can be monitored by passive acoustic stations such as C-PODs. By assuming that the number of clicks detected is correlated with the density of porpoises, this method can inform on relative changes in porpoise densities. In Denmark, 6 Marine Protected Areas (MPAs) designated for porpoises have been monitored with C-PODs during 2012–2016. This study aimed to evaluate the statistical power to detect trends in such monitoring schemes. In each MPA, five C-POD stations collected data over two periods for 12–16 months each. Porpoise detections were parameterized as the average daily number of minutes with acoustic porpoise detections (Porpoise Positive Minutes) per month. For each station, differences in PPM between periods were compared using mixed-effects ANOVA. Power analysis showed that five stations recording for a full year was sufficient to detect a 5-20% change in animal density from one year to the next with 80% power and an alpha level of 0.2. Increasing the number of stations or monitoring months did not increased the power considerably. In five out of six MPAs, PPM increased significantly (by 19-32%) from the first year of deployment to the next. In the last MPA, no significant change was found and here, the power to detect a trend was much lower which may be due to lower detected levels of PPM in this MPA. Based on the current data, we conclude that passive acoustic monitoring using 5 stations for a full year provide sufficient power to monitor the long-term status of porpoises in MPAs.

Socio-economic models for marine conservation: The illegal wildlife trade in Caspian seal (Pusa caspica) products.

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The illegal wildlife trade (IWT) in products from marine ecosystems is a global threat to biodiversity and is steadily escalating. Conservation biologists are now developing methods to investigate the volumes, scale and scope of such trade and how it influences the demography of exploited species. The population of Caspian seals has declined by around 90% in the last 100 years, primarily due to historic over-exploitation. Although organised commercial hunting ceased in the 1990s, the population is not recovering due to high levels of by-catch associated with illegal sturgeon fisheries. Seal fur, and blubber rendered to oil, originating

from by-caught and hunted seals form the basis of a substantial illegal commodity chain in the Caspian region. Here we show that a network modelling approach can be used to assess IWT impacts on the Caspian seal population, parameterised using data on by-catch rates and volumes of seal products traded through the IWT supply chain. Data on Caspian seal IWT were collected over 12 months (2018-19) in Dagestan, Russia, using interviews with fishers selected by probability sampling (n=120), and a full population survey with IWT actors, most notably, middlemen and seal product traders. Reported numbers of seals taken by Fishers in Dagestan, combined with data on traded product volumes, suggest a minimum of 3000-5000 animals entering the commodity chain per fishing season. Analysis of 191 trade partnerships show the trade is structured across a maximum of 7 levels in a network extending across Russia, involving the economic activity of tens of thousands of people. As well evaluating the demographic consequences for the seal population, this study can help understand the socio-economic drivers of the trade, and identify potential points of intervention or possibilities to incentivise alternative livelihoods. We suggest that this approach could be applied to studying small-boat fishery-marine mammal interactions worldwide.

Seeing the northern fur seals from the boulders: Developing an UAS approach for abundance assessments.

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In 1963, NOAA Fisheries' Marine Mammal Laboratory (MML) began to use the mark-recapture method of shear-sampling northern fur seal pups to estimate pup abundance. Presently, these surveys are conducted biennually on St. Paul and St. George Island (Pribilof Islands, Alaska), requiring up to 22 people over the course of 2 and 3 weeks. The presence on rookeries poses potential safety risks to the scientists and creates disturbance of fur seals (authorized by a Federal permit NMFS/MMPA 14327 and IACUC ANW2013-3). MML began to use unoccupied aircraft system (UAS; i.e., drones) to augment Steller sea lion surveys in 2014 and have been working towards developing an UAS-based method for northern fur seal abundance surveys. The greatest challenge with our preliminary efforts was identifying fur seals from the background. In the summer of 2018, we collected spectral radiance measurements of northern fur seals and the background (rocks, grass, etc.) with an ASD FieldSpec 3 Spectroradiometer on St. George Island. These ground measurements were used in modeling and simulation to assess whether multi-spectral imaging (0.35 to 2.25 μm or visible to shortwave infrared spectral region) is feasible for better distinguishing fur seals. MML also used a heavy-lift hexacopter (APH-28) to conduct multiple UAS surveys of a small rookery with a FLIR DUO Pro R thermal sensor (with lower resolution visual imaging capabilities) and redundant surveys with an Olympus E-PM2 (25mm lens) mirrorless visual camera. UAS imagery counts (thermal-visual paired and high-resolution visual) will be compared to the traditional shear-sampling method. Preliminary data indicates that northern fur seals could be easily distinguished from the background using multi-spectral imagery. Assessing optimal imaging capabilities will guide sensor selection and then MML can explore which UAS platforms would be most effective for surveys to replace the traditional method.

Variation in ship noise perception by narwhal (Monodon monoceros), bowhead whale (Eubalaena glacialis) and ringed seal (Phoca hispida) along a shipping route in Northern Baffin Island, Canada.

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Underwater noise created by ships can mask marine mammal communication and disrupt natural behaviour. Increasing shipping in the Arctic exposes marine mammals to higher levels of anthropogenic sound in a formerly pristine environment. Weighting functions adjust received noise levels across frequencies as they would be perceived by different groups of marine mammals. Weighting functions may indicate which species face higher exposure to ship noise. This study uses ship-based AIS data and applies weighting functions (Southall et al, 2019) for high and low frequency cetaceans (HF, LF), and phocids (PCW) to acoustic recordings along a shipping route near a sheltered Inlet in Northern Baffin

Island, Canada. The goal is to use the weighting functions to assess perceived broadband underwater noise levels from passing ore carriers. An Autonomous Multichannel Acoustic Recorder (AMAR) deployed from 4 August to 28 September, 2018 collected minute-by-minute levels in third octave bands with a continuous duty cycle. Broadband noise levels (10 Hz to 31.5 kHz) were calculated using linear and the three auditory weighting functions. Ship distances and orientation relative to the recorder were calculated to estimate the increase in noise level for each hearing group. All weighting functions showed reduced received levels from linear broadband when a ship was present. The highest LF, PCW and HF broadband levels were 7, 16 and 25 dB respectively lower than the linear levels. Received levels increased above ambient for HF when ships were 2.5-3 km away, and for PCW and LF, at 8-10 km. The highest noise levels occurred when the ore laden ships were facing away from the recorder. Noise levels increased above ambient for 25 minutes for HF and 80 minutes for the PCW and LF per ship transit. This study highlights the importance of accounting for the hearing abilities of different species in noise assessment studies.

An increase of harbour porpoises in Polish waters? A case study using passive acoustic monitoring.

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Passive acoustic monitoring (PAM) is a suitable tool to detect the presence of cetaceans in a given study area and to investigate changes in occurrence of the target species over time. Between 2011 and 2013, a large scale PAM study was undertaken to investigate the occurrence of endangered harbor porpoises in the Baltic Sea (SAMBAH project). SAMBAH indicated a clear gradient in occurrence with higher porpoise detections in the Northwestern Baltic compared to the Southeastern part including Polish waters. The SAMBAH data indicated that in Polish waters porpoise abundance might be extremely low. Since the SAMBAH study was conducted over the period of only two years, it was not known how stable the documented distribution pattern are. In this study we investigated whether for Polish marine waters, the results obtained during the SAMBAH project could be validated for subsequent years and thus considered representative. The research was carried out in 2016-2018 in two subareas located in the Western and Eastern part of the Polish EEZ. A total of 10 automated porpoise click detectors (C-PODs, Chelonia Ltd.) were used for the data collection. The results showed that the spatial gradient of occurrence of the species which was found in the previous studies was preserved. However, the number of detections of harbour porpoises was much higher compared to the former investigation indicating a much higher number of animals present. Our study shows that presence of cetaceans can change dramatically between relatively short periods of time. This may be due to shifts in prey distribution. We conclude that PAM on harbor porpoises should be carried out over longer periods to get a better picture on the status of this endangered population in the Baltic.

Harbor porpoise sex life: Are lateralized and aerial mating behaviors characteristic throughout their range?

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Harbor porpoises (*Phocoena phocoena*) have a reputation for being inconspicuous, and reports of aerial behavior are rare despite the species' common nearshore occurrence across a wide range in the northern hemisphere. Recent description of their mating habits in San Francisco Bay revealed that males often become fully or partially airborne as a consequence of their rapid sexual approaches to females (69% of mating attempts, $n = 85$) and that aerial behavior occurred only in a mating context. Furthermore, males always attempted to copulate by positioning their ventral side on the females' left side (100% of approaches, $n = 142$), typically perpendicular to her level position at the surface. Because these findings were limited to the non-migratory San Francisco-Russian River stock (a subpopulation of *P. p. vomerina*), our goal now is to determine whether this high-energy lateralized mating results in aerial behavior in other stocks and

subspecies of harbor porpoises. Preliminary results based on photographic records confirmed this same suite of behaviors from 10 other locations in the Pacific and Atlantic Oceans: Monterey Bay, California, USA; Burrows Pass, and Southern Puget Sound, Washington, USA; Prince Rupert, British Columbia, Canada; Cornwall, England; Devon, England; Shetland Islands, Scotland; Eastern Scheldt, Netherlands; Great Belt, Denmark; and The Kattegat, Sweden. We are seeking additional collaborative input on harbor porpoise behavior across the species' entire range. Researchers should be aware that aerial behavior may be a sign of mating activity, rather than foraging. Resource managers should factor observations of such behaviors into conservation and development decisions affecting potential breeding hotspots.

Drone videos: A new method for photogrammetry of fin whales (Balaenoptera physalus)?

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Photogrammetry is a method that has been used to measure different characteristics of cetaceans. However, it is mostly based on the use of laser-metrics from vessels, or aerial photographs from aircrafts. We propose a non-invasive and coast-effective option, which can be used at sea, simultaneously with photo-identification techniques for fin whales (*Balaenoptera physalus*). We explored the usage of unmanned aerial vehicle (UAV, drone) images and videos to develop a new measurement method of individual fin whales off the Catalan coast. The drone-made videos enabled us to acquire a large amount of high-resolution vertical images of the head and the full body of the same individual and implement relative measurements. Due to the subsequent images, we were also able to account for measurement errors and the variability of these characteristics. In the present study, we obtained 427 videos over a 4 years period from 2015 to 2018. Due to the unique pattern of the chevron of fin whales, we were able to identify 84 animals, from which we selected a subset of 30 individuals for measurements, which had the best footage of the desired body axis. The relative measurements of the head and body were used to estimate full body length and the leanness with the size of the girth. We compared the relative values with the size of the boat, but also with other individuals, the data of the same individual within the year and between years, to see if there is growth and to examine the longevity of the characteristics. Such data are important, since it can provide information on the species. The acquired ratios can further be used to estimate body condition and nutritional status, and as such the health of the individual, which is crucial for our knowledge of the survival of the animal and the population.

Environmental DNA for assessing habitat use and genetic diversity of bowhead whales

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One of the major obstacles in assessing the effects of climate change on Arctic ecosystem is the logistical and methodological challenges associated with data collection in remote, harsh environments. Thus information on the status and pressures affecting e.g. Arctic marine mammals is often restricted to certain species and/or geographical regions. Here we tested the applicability of environmental DNA (eDNA) as a simple, non-invasive and cost-effective tool for assessing the distribution, abundance and diversity of the spring aggregation of bowhead whales (*Balaena mysticetus*) in Disko Bay, Western Greenland. First, we extracted DNA from 150 water samples collected during May 2017 and 2018 from the "footprints" of diving whales or along random transects. Next, using novel bowhead whale qPCR probes we obtained an eDNA-based relative estimate of bowhead whale distribution, nicely correlating with the visually observed occurrence of whales. Moreover, we show that the genetic profiles obtained from footprints of individual whales match the profiles obtained from skin biopsies. Thus, by sequencing all water samples with presence of bowhead DNA we were able to reconstruct the mtDNA haplotype distribution and frequencies estimated through more than a decade of biopsy sampling and genetic profiling of bowhead whales in Western Greenland. As such, our study demonstrates the large potential for routine eDNA monitoring and population genetic inference of not just bowhead whales, but also other marine mammals.

Sequencing the mitochondrial genome of bowhead whales (Balaena mysticetus) from environmental DNA

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Monitoring cetaceans with the use of environmental DNA (eDNA) is a novel approach in marine mammal research. Collecting water samples from the close vicinity of individuals is simple, inexpensive and nevertheless non-invasive, thus eDNA has a potential in complementing traditional survey methods.

In this study we tested if eDNA has the capacity to capture enough genetic material of cetaceans for sequencing full mitochondrial genomes.

Applying eDNA to answer questions related to population genomics of cetaceans is challenging. The quality of eDNA in seawater reduces with time and the majority of the extracted DNA from water belong to organisms that are the most abundant in seawater (eg. Bacteria). However, cetaceans often leave genetic material behind (eg. sloughed skin) while swimming through the water column. Water samples can be collected at the location of the final dive (footprint). Footprints can be easily detected visually and are likely to contain cellular material from the diving whale.

Surface water samples from footprints of individual bowhead whales were collected in Disko Bay, Western Greenland. The filtered eDNA samples were quantified with bowhead whale-specific qPCR probes. The eDNA samples that yielded high copy number of bowhead whale DNA were used to generate whole-genome shotgun sequences with Illumina HiSeq platform. Sequences were mapped to a reference bowhead whale mitogenome.

The results indicate that sequencing mitogenomes from eDNA samples can be a novel tool for population genomics and could provide a platform to monitor cetacean populations without the necessity of invasive techniques. Implementing eDNA to population genomics is not only beneficial for endangered species, where disturbance should be kept to a minimum, but also for rare and elusive species that are difficult to sample and monitor with conventional survey methods.

Use of social network analysis to understand disease transmission and its impacts on a Northeast Florida estuarine dolphin population

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The St. Johns River (SJR) in Northeast Florida is an estuarine system inhabited by bottlenose dolphins (*Tursiops truncatus*). These dolphins live in complex, fission-fusion societies, associating with other individuals in groups often changing in size and composition. Between 2013 and 2015, SJR dolphins were impacted by an unusual mortality event (UME), caused by cetacean morbillivirus (CeMV), that was originally thought to be limited to coastal dolphin populations. This study analyzes how transmission of this disease may have been influenced by social interactions among dolphins within the SJR. Weekly photo-identification surveys were conducted between Nov. 2011-Oct. 2016 (n=189). Groups were defined using the 10m chain rule. Sighting histories were divided into three time periods: Pre-UME (Nov. 2011-Jun. 2013), During-UME (Jul. 2013-Feb. 2015), Post-UME (Mar. 2015-Oct. 2016). For each time period, half-weight indices of association (HWI) and several network measurements were calculated using SOCPROG v. 2.8. Mean HWI was significantly lower During-UME than the other two time periods (Pre-UME=0.048; During-UME=0.035; Post-UME=0.048; $p<0.017$). Weaker associations and decreased connectivity may have been a way for dolphins to avoid further spread of the contagion. However, maximum HWIs were sustained between Pre-UME (mean=0.515) and During-UME periods (mean=0.476; $p=0.158$), suggesting dolphins maintained preferential associations. Additionally, while reduced network measures and number of individuals present during the UME (Pre-UME: n=106, strength=5.01, reach=27.27, affinity=5.36; During-UME: n=90, strength=3.16, reach=11.68, affinity=3.49) may have been due to increased mortality, the Post-UME increase (n=130, strength=6.22, reach=42.28, affinity=6.71) suggests that dolphins may have moved out of the area during negative conditions. Centrality measures identified individuals with high likelihood of spreading CeMV throughout the network. Future research will use spatial analyses to determine the home ranges of dolphins during each time period, and analyze potential overlap of

CeMV+ stranded individuals to determine a possible path for disease transmission.

Bycatch reduction in Portuguese set nets

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In mainland Portugal, interactions between fisheries and cetaceans occur in almost all fishing gears. Data gathered between 2010-2015 showed that set nets (used in the Portuguese polyvalent fleet) led to harbour porpoise, common dolphin and bottlenose dolphin mortality values well above their national populations' maximum annual acceptable mortality limit. To address this severe bycatch problem, a mitigation essay using pingers was carried out in Portuguese set nets. The essay covered 352 fishing trips corresponding to 733 control fishing events (nets without pingers) and 627 experimental fishing events (nets with pingers). During the essay, five cetacean species (Common dolphin, Bottlenose dolphin, Harbour porpoise, Pilot whale and Balaenoptera sp) interacted with fishing gear. Considering the number of cetaceans involved in interactions, interaction rates were 2,4256 in control nets and 1,0144 in nets with pingers. The difference indicates a 58,18% lower interaction rate in experimental nets in comparison to nets without pingers. With respect to the number of cetaceans involved in interactions that resulted in mortality, the bycatch mortality rate was 0,0491 in control nets and 0,0207 in experimental nets. The difference indicates a 57,84% lower mortality rate in nets with pingers in comparison to nets without pingers. In particular, nets equipped with pingers revealed a 51,62% reduction of the common dolphin mortality rate, and an 83,29% reduction of the harbour porpoise mortality rate, in comparison to nets without pingers. A large-scale implementation of pingers in set nets would be challenging, considering the large size of the Portuguese fleet and the costs associated with pingers and their long-term maintenance. Therefore, in Portugal the use of pingers should be combined with good practice manuals, robust and cost-effective bycatch monitoring tools and awareness campaigns, especially in Marine Protected Areas targeting cetacean conservation.

Evaluation on activities of radiocesium released by the Fukushima Dai-ichi Nuclear Power Plant(FNPP1) accident damaged by The Great East Japan Earthquake. – preliminary study using stranded odontoceti-

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Radiocesium (^{134}Cs and ^{137}Cs) activity concentrations were measured to assess the radiocesium contamination in muscle tissues of stranded toothed whales (13 finless porpoises, one melon-headed whale, one sperm whale and one short-finned pilot whale) after the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident caused by the Great East Japan Earthquake on 11 March 2011. Except for one new-born sperm whale (< detection limit: 0.16 Bq/kg-wet for ^{137}Cs), ^{137}Cs (half-life: 30.1 y) were detected from all 13 finless porpoises collected 31–2185 days after the FDNPP accident at 111–221 km far from the FDNPP. Of these, ^{134}Cs (half-life: 2.06 y) were detected from 8 individuals. One finless porpoise collected in December 2011 from Sammu City (210 km south from the FDNPP) showed a high radiocesium concentration of 1620 Bq/kg-wet, whereas other individuals presented lower values (1.03–72.1 Bq/kg-wet) less than the Japanese regulatory limit

for foodstuff (100 Bq/kg). In contrast, radiocesium was not detected from a finless porpoise and a melon-headed whale collected before the FDNPP accident. Electron-prove X-ray microanalysis was undertaken on the testes of 2 finless porpoises and 3 melon-headed whales. ^{137}Cs was not detected in all of the testes. Parasitic granulomatous pneumonia and parasitic hepatitis in some of examined finless porpoises, and suppurative pneumonia in some melon-headed whale were found respectively, although these findings was not related with Radiocesium (^{134}Cs and ^{137}Cs) activity concentrations directly. Our result demonstrated that radiocesium released from the FDNPP was accumulated in toothed whales, although almost all the values were under the Japanese food safety level.

A comparison of the diet composition derived from skin stable isotopes and stomach contents for two baleen whale species: Sei and Bryde's whales in the western North Pacific.

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The common method for investigating diet of cetaceans is the identification of undigested prey items from the stomach contents. This method is believed to provide reliable information on the most recent prey prior to sampling. Recently stable isotope analyses have been developed and used to investigate diet composition in cetacean species. Using a Bayesian framework (SIAR), a stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope mixing model was used to assign diet composition to western North Pacific sei (*Balaenoptera borealis*) (n=180) and Bryde's (*B. edeni*) (n=50) whales (skin samples), and prey items: copepods (*Neocalanus spp.*), krills (*Euphausia spp.*), Japanese anchovy (*Engraulis japonicus*), Japanese sardine (*Sardinops melanostictus*), Pacific saury (*Cololabis saira*), mackerels (*Scomber spp.*) and North Pacific light fish (*Maurolicus japonicus*) in the western North Pacific during the summer of 2015 and 2016. Diet composition derived from the stable isotope and traditional stomach content analyses were compared. Both analyses suggested a larger diversity of preys in sei whale (six species) compared to Bryde's whale (three species; one accounting for over 95% of all contents). However, in the case of sei whale the diet composition differed between methods. The contribution of pelagic fish species was much higher in the stomach contents (about 85%) than in the stable isotope analysis (less than 20%). This result could be explained by: i) isotope analyses of skin provide information on the average composition of the diet weeks and even months prior to sampling, whereas the stomach content analyses give a snapshot of the whale's last meal (the simplicity in diet could explain the similarity of results in the case of the Bryde's whale); ii) possible seasonal/areal variation in the isotopic values of prey species, which was not examined in the present study.

Prey species of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in a small oceanic island revealed by the analysis of foraging behaviors and stomach contents.

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It is necessary to study the feeding ecology of animals for a better understanding of their life history and for their conservation. Previous studies have suggested that Indo-Pacific bottlenose dolphins (***Tursiops aduncus***) feed on a variety of species of fish and cephalopods, and that the prey species differ among populations. Therefore, it is important to list the prey species from each *T. aduncus* population. In Mikura Island, Japan, stranded and entangled dolphins, which usually provide the list of prey items, are rare because Mikura is a small oceanic island without beaches and intensive fisheries. Interviews with dolphin-swimming captains and guides, questionnaire surveys submitted via websites and SNS, and analysis of underwater footage for ID research of the 2015-2017 seasons were conducted to reveal the prey species of *T. aduncus* around Mikura Island. This evidence was then compared with the stomach contents of 10 individuals that were entangled mainly by gill nets around Mikura Island between 1996-2017. Dolphins around Mikura Island feed on a variety of prey species including 13 species of fish, 7 species of cephalopods and 1 species of crustaceans as prey species, and 9 species of fish and 1 species of crustacean as possible prey species. Octopus (***Octopodasp.***), flying fish (***Exocoetidae*sp.**) and

lizardfish (***Prionurus scalprum***) were the three dominant prey species which were observed during daytime underwater observations. Yellow striped butterfish (***Labracoglossa argenteiventris***) were found from the stomach contents of 40% of the entangled dolphins in the gill nets despite rarely being identified as prey species during daytime underwater observations, suggesting that entangled dolphins had taken the fish out of the gill nets before entanglement. Most dolphins observed feeding during the day were female (93% of 43 individuals). It was thought that nutrition demands might be different between male and females.

Behavioral responses of common bottlenose dolphins (Tursiops truncatus) to changes in salinity within the Barataria Basin in Louisiana

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More than 3,000 common bottlenose dolphins (*Tursiops truncatus*) are estimated to inhabit Barataria Basin (BB), Louisiana, USA, a highly productive estuary characterized by variable salinity driven by natural and man-made processes. It is unclear whether BB dolphins move in response to fluctuating salinity, which can at times decline to 0 parts per thousand (ppt) in portions of the basin. We temporarily caught and attached satellite-linked tags to 17 BB dolphins (10 females; 7 males) to evaluate fine-scale movements relative to modeled salinity trends. Wildlife Computer (N = 11) and Sirtrack (N = 6) satellite tags transmitted for a mean 144 $\pm$ 36 S.D. days and 101 $\pm$ 67 S.D. days, respectively, and provided on average 2.4 $\pm$ 1.0 S.D. and 0.2 $\pm$ 0.2 S.D. quality locations (3, 2, or 1) per day. We compared the dolphin locations to mean daily salinity estimates provided by the Water Institute of the Gulf from a Delft3D model. Despite extremely low-salinity conditions, most dolphins maintained a limited range (averaging 3.4 km net movement per day within 10–20 km of their capture locations). One dolphin spent 49 consecutive days in waters estimated to be under 7.5 ppt salinity. Two dolphins had unusually broad movement patterns (averaging 7.6 km net movement per day), with one traversing the east-west and north-south extremes of BB. However, despite the broad ranges, their movements were not associated with salinity gradient. Across our analyses, we found no evidence that any of the dolphins moved in response to salinity changes. Due to loss of wetlands in BB, sediment diversions from the Mississippi River are being planned and could bring extreme decreases in salinity across the BB. This study provides information on potential behavioral responses of dolphins and can inform study designs to monitor associated health impacts from the planned diversions.

Geographical and genetic origin of marine mammals strandings in the Yucatan Peninsula through the use of two biophysical modeling approach.

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Strandings are excellent sources of information since they allow scientific access to organisms that are very difficult to see in the wild. Several studies in the fields of pathology and population genetics, among others, have arisen from information gathered at these phenomena. However, population interpretations based on strandings lack certainty regarding the origin of the organisms, since, in some cases, organisms have been dragged hundreds of kilometers by currents, giving erroneous information about local populations. The present study aims to contribute to the knowledge of the population structure of marine mammals in Campeche, Yucatan, Quintana Roo and Belize. We determined the origin of strandings in the localities mentioned above using both, molecular markers and Lagrangian drift model. The genetic characterization of the recorded species was performed, comparing these with the information provided by databases to determine the

mitochondrial lineages present. To find the spatial origin of the stranding we used two ocean models: the Regional Ocean Modelling System (ROMS) and the Global Hybrid Coordinate Ocean Model (HYCOM). These models use several parameters like oceanic currents, date and geographic position of the stranding. To find the effect of the wind on the carcasses, we implemented a photogrammetry analysis. These models started from the point where the stranding occurred all the way to the probable geographic origin of death. To our knowledge, this type of research has not been done previously, we determined the trajectory of the carcasses, which in some cases exceeded 40 km, identifying recurring regions from which the strandings originate, even independently of the year or the climatic regime. These areas are generally coastal and close to urban centers, therefore related to high maritime traffic or intense fishing gear use. This suggests that strandings may be related to anthropic factors.

Long-term cetacean population presence and abundance in relation to moon cycles off Pico Island (Azores)

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Off Pico island (Azores), a long-term study has been focusing on monitoring cetacean species presence in the Bay of Ribeiras (230 km²). Data were collected through standardized land surveys from a fixed look-out post (using Steiner 20x80 binoculars) at 45m altitude. Surveys (average 20 mins. per survey) were conducted on a daily basis covering all tidal cycles with 2-hour intervals to avoid double counting. Next to standard environmental information, data was collected after Mann's (1999) point sampling method and the period analyzed included the years 2011 to 2018. During 964 days, covering 926 hours, 2613 dedicated surveys were conducted. A total of 19 species (3905 single sightings) were observed and clustered in 8 subcategories for further analysis: Balaenopteridae (n=5), Hyperoodon (n=1), Ziphiidae (n=3), Physeter (n=1), Globicephala (n=2), Grampus (n=1), Tursiops (n=1), Small Oceanic Delphinids (n=3). The effect of lunar cycles on cetacean species' presence and numbers were investigated running a Poisson regression model. To correct for the observation time, the number of sightings per moon phase were divided by the total hours observed. Grampus were present in almost 30% of all surveys, followed by Delphinids (27%) and Physeter (11%). A significant positive association between the lunar cycle and most cetacean species presence was detected during new moon, and after full moon (waxing crescent). Around full moon, cetacean species were less sighted and recorded in lower numbers. The relationship between lunar cycles and daytime cetacean presence may be linked to higher prey availability during different moon phases. Full moonlight is known to reduce organisms' vertical migration, with effects that trickle through the food web. This pattern concerns especially known night-foraging species such as Grampus and Globicephala, while most generalized (Tursiops) or deep-sea (Ziphiidae, Physeter) predators showed non-significant variation, suggesting that other environmental variables determine their presence.

Skin lesion prevalence of estuarine bottlenose dolphins (Tursiops truncatus) in the outer banks of North Carolina, with comparisons to other East coast study sites.

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Bottlenose dolphins are sentinels of environmental health. Skin lesions may indicate disease or contaminant exposure, and can be used to infer population health. We estimated skin lesion prevalence and identified major lesion types on estuarine bottlenose dolphins, *Tursiops truncatus*, in Roanoke Sound, North Carolina over a three-year period using photo-identification. Boat-based transect surveys were conducted from April 2012 through October 2014. Data were processed using FinBase. High quality images of distinctive fins were examined for the presence of any skin lesion (n=169; P= 0.51; 95% CI = 0.43-0.58). Prevalence estimates of nine lesion types were calculated. Roanoke Sound estimates were compared between years and seasons, as well as to dolphins photographed at three southern study sites. Overall Roanoke Sound lesion prevalence varied little between years and did not differ significantly from southern site estimates ($p>0.05$). In Roanoke Sound, most lesions were observed in the spring (P=0.79; 95% CI: 0.63-0.95). Pale lesions were most common (P=0.38; 95% CI: 0.28-0.49), occurring at a higher prevalence than southern sites ($p<0.05$). Skin lesions occurring on Roanoke

Sound dolphins are similar in type to those observed in southern sites, yet vary in prevalence. Future studies should correlate lesions with environmental variables and use stranded dolphins to predict lesion etiology.

The increasing role of citizen science in UK marine mammal policy and management.

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'Citizen science' historically had a reputation to many as amateur science which lacked quality control and yielded poor quality data with limited application to wider uses. With a myriad of organisations using a variety of data-collection protocols and volunteers with a broad scale of training, the data were generally only used by the organisations collecting them to promote their own messages. Since citizen science has gained impetus in recent years, these disparities are being addressed within e.g. the marine mammal community, making significant progress in improving the data-collection process. Volumes of marine mammal data are collected by UK citizen scientists, which is increasingly being used by the scientific community and contributing to policy decisions.

Marine data can be costly to collect; therefore, evidence collected through the national budget is often reactive to a specific need, or spatially/temporally limited. The resource that is available through citizen science data collection in the UK alone is vast. The value of such data is exemplified by the UK's Joint Cetacean Protocol which collated datasets amounting to over a million km of survey effort, much of which was citizen science data. This was analysed to investigate spatial and temporal trends in the abundance and distribution of cetaceans and more recently used to support the designation of MPAs for harbour porpoise. Predicted cetacean density from this resource are used routinely by industry for impact assessments, and statutory bodies in their advice for Regulators. These data also contribute to national reporting such as the EU Habitat's Directive assessment of conservation status.

The value of these citizen science initiatives has been demonstrated in the UK and there's a further need to build on this and ensure protocols, training, data storage and access are synthesised to make the most of this resource in contributing to the conservation and management of marine mammals.

Persistent organic pollutants in two declining Australian pinniped populations.

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Persistent organic pollutants (POPs) are contaminants that cause immunosuppression, immunomodulation, endocrine dysfunction and neoplasia. Little is known of marine mammal exposure to POPs in the Southern Hemisphere. For the endangered Australian sea lion (*Neophoca cinerea*), the investigation of anthropogenic pollution is identified as a key *knowledge gap* and area of research *critical* to the species' recovery plan.

The aim of this study was to determine the concentrations of polychlorinated biphenyls (PCBs), dioxin/furans, polybrominated diphenyl ethers (PBDEs) and, per- and poly-fluoroalkyl substances (PFAS) in sample matrices from two pinniped populations with declining pup production. *N. cinerea* pups were sampled at Seal Bay, Kangaroo Island; Australian fur seal (*Arctocephalus pusillus doriferus)* pups were sampled at Seal Rocks, Victoria. In addition, POPs concentrations were determined in *A.p. doriferus* stranded along the Victorian coast.

High resolution gas chromatograph-mass spectrometry (HRMS) and liquid chromatograph-mass spectrometry (LCMS) detected POPs in all tissue matrices analysed; highest concentrations were detected in blubber. In *N. cinerea* pups, liver PFAS (ΣPFAS = 14488 ± 6657pg/g ww) and blubber dioxin-like PCB (Σdl-PCB = 3585 ± 2883pg/g ww) concentrations were lower than reported concentrations for pinnipeds in the Northern Hemisphere. In *A. p. doriferus* pups, the concentration of dl-PCBs in fur were Σdl-PCB = 646 ± 423pg/g ww, while significantly higher concentrations were detected in the blubber of stranded individuals (Σdl-PCB = 5,615,786 ± 2,606,393pg/g ww).

This study has key conservation and management outcomes for two declining populations highlighting maternal transfer of POPs and the utility of fur as a novel, minimally invasive sample for POPs analysis. While the role of anthropogenic toxicants in reduced pup production is unclear, associations with stranding and detection of these compounds in endangered and declining

populations demonstrates the ubiquitous nature of these toxicants in the marine ecosystem.

High harbour porpoise echolocation activity close to oil and gas platforms indicates a strong artificial reef attraction

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The harbour porpoise, is the most common marine mammal in the central North Sea where offshore oil and gas installations are concentrated. Porpoises have been reported to show avoidance or altered behaviour in response to noise emitted during offshore activities such as shipping, seismic, drilling, wind farms and pile driving. Less well understood are responses of porpoises to sounds emitted from oil and gas platforms during routine operations, which may represent a permanent disturbance leading to possible habitat exclusion. However, offshore constructions may also act as artificial reefs with increased biodiversity and prey abundance leading to habitat attraction. To investigate the presence and feeding behaviour of harbour porpoises around a large production platform, we deployed autonomous acoustic loggers, recording continuously for two years, at 18 stations between 0 and 26 km from the platform. Click detectors recorded porpoise echolocation activity at all stations while broadband loggers recorded underwater noise at five stations. Harbour porpoises were detected at all distances, year-round in both years, however, two distinct seasonal activity patterns were found. During July-January, porpoises were attracted to the platform with high echolocation and feeding activity within 800 m of the platform, lower activity at 3-10 km, and again increased activity at 13 km and beyond. During February-June, porpoises were deterred from the immediate vicinity of the platform, while stations from 200 m to 26 km recorded uniformly, and lower, porpoise activity compared to July-January. Noise levels were elevated by up to 25 dB (at 5 kHz) closest to the platform and decreased to background levels at 13 km. These results indicate that offshore oil and gas platforms can act as artificial reefs attracting harbour porpoises in search of prey despite increased noise level. Offshore industrial structures may be important for ecosystems in an overexploited environment by acting as artificial reefs.

Trophic niche comparison among sympatric coastal dolphins off Southwest Atlantic Ocean

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Sympatric species are expected to minimize potential competition by specializing on distinct resources or exhibiting differences in when or where resources are exploited. Therefore, a comparison of ecological niches can be important to evaluate underlying mechanisms of coexistence and eventually predict community responses to ecosystem changes. Here, we assess the trophic relationships among three sympatric dolphin species from Santa Catarina State - southern Brazil: the franciscana dolphin (*Pontoporia blainvillei*), the Guiana dolphin (*Sotalia guianensis*), and the coastal ecotype of bottlenose dolphin (*Tursiops truncatus gephyreus*). We evaluate the temporal variation of $\delta^{13}C$ and $\delta^{15}N$ stable isotopes in bone collagen to test dietary shifts and estimate the degree of niche overlap among these species using ellipses area (SEAc) through SIBER (Stable Isotope Bayesian Ellipses in R). In addition, we evaluate the contribution of potential prey to their diet using Bayesian mixing models. The $\delta^{15}N$ values were consistent across years, while $\delta^{13}C$ values decreased for bottlenose dolphin, suggesting variation in feeding areas through time. The franciscana dolphin showed the narrowest niche width and occupied the highest trophic level, whereas the bottlenose dolphin occupied the lowest trophic level with the broadest niche width. The trophic niche of Guiana dolphin was fully contained within the trophic niche of bottlenose dolphin, reflecting the high contribution of demersal prey species in both species' diets. In contrast, the franciscana diet is mainly composed by pelagic prey species, resulting in a lower niche

overlap with Guiana and bottlenose dolphins. To the best of our knowledge, this is the first study to evaluate resource use and niche overlap within the unique area were these three dolphin species coexist. Further compound-specific stable isotope analysis of amino acids is being processed and will generate additional data about resource use and habitat preferences of these coastal species in the study area.

Osteological descriptions of Steno bredanensis in the Canary Islands

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In the Canary archipelago, 30 species of cetaceans have been recorded in its waters, 27 of which have one or some stranding records since the 1980s to date. One of these, the "rough-toothed dolphin" *Steno bredanensis*, is globally poorly known and there are few data on the osteology of this species from a few regions. Here we present the first osteological study of *Steno bredanensis* from the Canary Islands to increase the knowledge about the taxonomy and adaptations of the species. We carried out osteological analyses of different bones of 27 specimens stranded in the Canary Islands, including 17 complete skeletons. The results were compared within each other and by sex, as well as with other cetacean species, mainly Delphinidae species present in the archipelago. The skeletal ontogeny was analyzed in specimens with a total length between 82cm and 236cm., contrasting the fusion degree of the various cranial sutures and the synostosis of the vertebral complex, the sternum, the hyoid and the proximal pectoral region. An adult female was studied separately as it presented a different axial skeleton to the rest of the analyzed specimens as well as to the published data from other regions, highlighting a significantly higher number of vertebrae, and a sternum resembling other delphinids. The results of the studied specimens suggest the presence in the Canary Islands of two forms, one smaller, as well as sexual dimorphism identified in some metric variables of the skull. All studied animals presented dental furrows characteristic of the species, regardless the stage of development. This study contributes to implement the current knowledge of *Steno bredanensis*.

Impacts on odontocete occurrence from offshore construction using a novel anchoring system

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Continued global development of the offshore wind energy sector for the provision of clean, renewable energy is a pillar of the fight against human-induced climate change. Yet, the potential for unintended long and short-term environmental consequences of their construction is well established, albeit spatially inconsistent and species specific. Pile-driving is perhaps the most commonly cited element of the construction process with regard to negative environmental impacts, with a need for alternative anchoring methods often proposed. A novel gravity-base foundation, used by EDF Energy at its newly installed five turbine facility in a testing site off of Northumberland in the United Kingdom, is one such alternative.

The study presented here represents a unique opportunity to monitor and assess the occurrence of odontocetes pre, during and post construction in this testing site. Thus, allowing for initial inferences on the potential impacts of this novel anchoring alternative on locally occurring odontocetes. The area is frequented year round by three commonly occurring species with sensitivity to environmental disturbance (*Phocoena phocoena*, *Lagenorhynchus albirostris*, and *Tursiops truncatus*). Data were collected using passive acoustic monitoring (C-PODs) from June 2015 until October 2018, across nine sampling locations at varying distances from the installation site. Data analyses were carried out using generalised additive mixed models. The results reveal previously unknown spatio-temporal patterns in the occurrence of porpoise and delphinids, and indicate likely area exclusion of porpoises resulting from inter-specific competition. Further, the analyses indicate substantial effects of a range of environmental and anthropogenic variables on the occurrence of these species. With these effects accounted for specific note is made of the apparent short and long-term impacts of gravity-based foundation wind farm construction and the spatial nature and degree of apparent impacts are

discussed in the context of future technological development in this sector.

Scans of the beach; International assessment of harbour porpoise strandings along the North Sea coastline.

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The next decade is expected to see significant expansion of anthropogenic activities in the North Sea. The need to understand and quantify the impact of these on marine mammal populations is critical in order to design and assess effective mitigation and population management. Harbour porpoises are the most abundant cetacean species in this area. Highly mobile and elusive, they are notoriously difficult to monitor, but the coastline provides a powerful vantage from which to conduct surveillance, particularly on biological and health parameters. Information on stranded individuals are recorded on a national level, yet for this study, data from all the five national stranding networks bordering the North Sea were combined.

This work demonstrates the first assessment of the North Sea population as one ecological unit. Data from 1990-2017 were used to investigate spatiotemporal trends and assess biological characteristics of the stranded population. A total of 16,247 individual strandings were recorded. Stranding numbers increased annually in all regions, with a sharp increase in the southern North Sea after 2004. A Generalised Additive Mixed Model framework revealed a region-specific seasonal pattern, enabling detection of periods of unusual mortality. There was heterogeneity in age-specific sex ratio, with particularly high presence of juvenile males in the southern North Sea, possibly suggesting a population sink. The majority of neonate strandings occurred along the northern Dutch, German, and Danish coastlines, potentially suggestive of areas of importance for calving. The study provided unique high-resolution insight into region-specific population parameters of North Sea harbour porpoises. This new knowledge comes as a valuable addition to live animal survey data. Combined, these data sources can inform planning consent decisions and mitigation of impacts of offshore anthropogenic activities. This work demonstrates the value of a transboundary approach to data analysis for deriving effective conservation and management strategies of highly mobile marine species.

Ontogeny of muscle physiology in arctic seals

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Marine mammals must store and efficiently use oxygen while diving. Although oxygen is distributed across lung, blood, and muscle reservoirs, skeletal muscles play a substantial role in defining diving capacities. In general, locomotor muscles of marine mammals have large oxygen reserves to fuel aerobic metabolism at depth, but must also be capable of managing the buildup of anaerobic byproducts. Further, pups are not born with the same physiological capacities as adults, with aerobic and anaerobic abilities typically developing at the onset of independent foraging. Knowledge of species- and age-specific skeletal muscle physiology can inform understanding of diving constraints and behavioral flexibility. We examined myoglobin content ([Mb]) and non-bicarbonate buffering capacity (β) of a major locomotor muscle, the longissimus dorsi, in three Arctic seal species. Samples were obtained from ringed (*Pusa hispida*; n=11), bearded (*Erignathus barbatus*; n=37), and spotted (*Phoca largha*; n=12) seals in collaboration with native Alaskan subsistence hunters. We found adult ringed seal

muscle [Mb] to be 6.4±0.5 g Mb 100 g wet tissue^{-1}, while adult spotted seal muscle [Mb] was 5.5±0.5 g Mb 100 g wet tissue^{-1}. These data agree with previously reported values for other phocid species. In contrast, adult bearded seals had much lower muscle [Mb] (4.6±0.4 g Mb 100 g wet tissue^{-1}), making their muscle physiology more similar to benthically foraging walruses than to other phocids. Overall, we documented increasing ontogenetic trends in [Mb] and β for all three species; however, bearded seals exhibited more subtle developmental patterns. Our data suggest a strong link between muscle physiology, life-history strategies, and foraging behavior, and provide insight into the ontogeny of diving capacities and limitations in data-deficient species.

Kinematic detection of prey capture reveals sex reversals in foraging behavior between two populations of fish-eating killer whales

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Obtaining sufficient prey to meet energetic requirements is critical for survival and reproduction. For cetaceans that feed cooperatively or share prey, sex can be an important factor determining foraging behavior. Interference from human activities, however, can potentially alter social structure and foraging behavior, and consequently foraging outcomes, which may impact population status. Identifying foraging outcomes has been limited by the challenges of detecting successful subsurface prey capture events. We sought to quantify population differences in foraging outcomes between two partially-sympatric populations of fish-eating killer whales residing in the coastal waters of the northeastern Pacific ocean, which have exhibited opposite trends in growth and recruitment over the past two decades. Specifically, we tested the hypotheses that (1) foraging outcomes are related to population status, and (2) sex patterns in foraging behavior differ based on population status. Using sound and movement data from suction cup-attached Dtags concurrently deployed on 52 individuals from both populations, we detected acoustic and kinematic signatures of searching and prey capture, respectively, to quantify foraging events, and computed foraging metrics including foraging rate, prey capture failure rate and searching effort. We constructed mixed effects models to determine the importance of population, sex, deployment duration, deployment ID, and year on our foraging metrics, and iteratively dropped non-significant terms to arrive at the best models. We found that foraging and failure rates as well as searching effort were affected by an interaction between population and sex: whereas females from the endangered Southern Resident killer whale population exhibited less foraging activity than their male counterparts, the converse was true for Northern Resident killer whales. We discuss these results in the context of differing levels of human disturbance, unbalanced demographic structure and different population growth trajectories between populations, and the implications of sex-based foraging differences on population recovery.

Social structure of indo-pacific humpback dolphin (Sousa chinensis) in the matang important marine mammal area in Perak, Malaysia

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Social structure is the product of adaptive behaviour strategies in response to different ecological pressures to maximize individual fitness. As highly complex social animals, cetaceans exhibit various behaviours and have great diversity in their social structure throughout their global range. In this study, the social structure of the Indo-Pacific humpback dolphin (*Sousa chinensis*) in the Matang Important Marine Mammal Area (IMMA)

was investigated between 2013 and 2016. The association patterns were assessed using photo-identification techniques and measured by Half Weight Index (HWI) in SOCPROG program. A total of 105 group sightings across 14 boat-based survey over 125 days were included in the association analysis. Out of the 377 marked dolphin individuals, 41 were identified in at least 5 sampling periods. These individuals yielded a mean HWI of 0.15 ± 0.06 and social differentiation of 0.51, indicating well differentiated societies with weak associations between pairs. The distribution of maximum HWI association levels observed for each individual suggested that most individuals (80.5%, n=41) were not associated with any particular companion any more than expected if all individuals associated at random. However, the average-linkage cluster analysis showed that 15 individuals form relatively stronger association with each other (HWI ≥ 0.5). The stronger association observed among the 15 individuals suggested the influence of ranging patterns of the dolphins, whereby they were mostly found occurring within the estuary that restrict them to a smaller ranging area. This resulted in similar ranging patterns and increased their likelihood of association, as contrary to the dolphins that were sighted further from the coast and have a wider ranging area. Such research is important as it provides insights on the factors shaping the sociality in this species and can contribute towards the protection of the species through informed decision-making for the conservation of its habitats in the Matang IMMA.

Fin whale trends in the Mediterranean sea from the FLT MED MonNet long-term monitoring program

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The "Vulnerable" Mediterranean fin whale has been identified as a key species for the definition of Good Environmental Status for the Mediterranean Region within the MSFD (Directive 2008/56/EC). The assessment of species distribution, population trends and relative abundance are then a priority for member states. National monitoring programs have been carried out with little international agreement on methods and temporal-spatial coverage. We use data collected within a long term monitoring program from 2007 to 2017 to identify trends within 2 consecutive periods 2007-2012 and 2013-2017 as well as changes in species distribution within the Mediterranean region and 4 sub regions. Further analysis at smaller spatial scales (i.e. national EEZs) have been conducted to inspect intra-regional differences. Data have been collected by 8 research groups, embarking dedicated observers from June to September on board of ferries crossing the Mediterranean Basins. 10 Fixed transects lying in territorial waters of Italy, France, Spain, Tunisia and Greece have been surveyed on a bi-weekly or weekly basis, for a total of 1221 surveys accounting for 1709 fin whale sightings. Ferries used varied in size, with heights of observation platforms ranging from 15 to 29m. Distance Sampling analysis has been used to assess Effective Width Strip for different vessels. Relative Abundance Index for each survey has then been computed at 3 spatial scales (regional-SubRegional-EEZs) on a yearly basis and then analyzed according to the above mentioned periods. Dataset collected represent a unique opportunity to obtain reliable estimates of population trends over a decade and highlight the effectiveness of long term monitoring program for MSFD objectives.

Occurrence and characteristics of signature whistles in wild bottlenose dolphins from the Ligurian Sea (Italy)

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Bottlenose dolphins (*Tursiops truncatus*) make extensive use of narrowband whistles for intraspecific communication. Among the whistle types, each individual develops a unique whistle modulation pattern that broadcast its identity: the signature whistle. Although signature whistles have been extensively studied over the last 50 years in captive dolphins, studies on wild dolphins are rare because of the difficulties involved in recording unrestrained individuals. In our study, we investigated the acoustic structure and contextual use of the signature whistles of the bottlenose dolphins inhabiting the western Ligurian coast (Italy), within the Pelagos Sanctuary (NW Mediterranean Sea). This demographic unit is composed of nearly 250 individuals and has been studied since 2001. Surveys were conducted from July to October 2018, resulting in 25 encounters with the target species (average groups size 13.4 ± 9.14). Photo-ID data were collected with a digital reflex camera Nikon 7000 equipped with a zoom Nikon 70-200. Acoustic recordings were collected using an HTI-96-MIN hydrophone connected to a Zoom H5 Handy recorder (sampling rate 96 kHz). The visual inspection of spectrograms allowed us to identify 936 whistles. Among these, using the SIGnature IDentification (SIGID) method, 504 whistles were identified as signature whistles and grouped into 17 different categories of frequency modulation. Hence, for each whistle, we extracted the frequency contour using the Beluga toolbox for MATLAB and we measured eight acoustic parameters. The 17 signature whistle types were then statistically validated using a stepwise leave-one-out Discriminant Function Analysis (DFA). Photo-ID data were visually analysed and 83 individuals were positively identified. Finally, we investigated the relationships between signature whistles occurrence and the context as well as the presence of photo-ID individuals in the pod. Our results provide the first insight into the characteristics and contextual use of signature whistles in this population of wild bottlenose dolphins.

Conservation of Irrawaddy dolphins in Bago City and Municipality of Pulupandan, Philippines: A multi-sectoral approach.
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A Multidisciplinary research project was conducted in support of the efforts to conserve the Irrawaddy dolphins in the coastal waters of Bago City and Pulupandan, Philippines through the establishment of Marine Protected Areas (MPAs). Phase 1 of the project focused on the drafting of policies and management plan necessary in the setting up of MPA anchored on data on the updated dolphin population estimates, inventory of fishes, socio-economic profile, stakeholders' awareness and perceptions on Irrawaddy dolphins and MPAs in the locality. Phase 2 is a continuation of dolphin and fish monitoring with additional studies on water quality, tourism potential, livelihood, and project assessment. Phase 2 was done to formulate integrative strategies to ascertain the sustainability of the MPAs. The research project used the Multi-Sectoral Approach (MSA) involving local stakeholders in the project and in the post-project activities to include information and education campaign and drafting and approval of MPA management plan and ordinances. The more pronounced challenges encountered using the MSA include the i) difficulty of engaging community members in the project because of economic reasons, and ii) diminishing support of local government due to changing local priorities as affected by the programs initiated by national government. Overall, it is imperative to sustain the current conservation efforts through exploring more innovative partnerships given the following evidence-based local realities: i) declining population of endangered Irrawaddy dolphins in the locality, ii) community members are living below the poverty line, and iii) a significant number of community members are not aware of the presence of the Irrawaddy dolphins in their locality. More importantly, the current efforts should also take cognizance from the recent re-categorization that has raised the status of Irrawaddy dolphins in Guimaras Strait from ***vulnerable*** to ***critically endangered*** by International Union of Conservation for Nature.

Short-term effects of airgun pulses on narwhals.
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The narwhal (*Monodon monoceros*) is a high Arctic species inhabiting areas that are now experiencing marked changes due to climate change and an associated increase in anthropogenic activities. The sensitivity of narwhals to seismic exploration was studied in two integrative experiments in August 2017 and 2018 in East Greenland. The study exposed narwhals (n = 9) instrumented with satellite transmitters and behavioral-physiological-acoustic sensors to airgun pulses. The whales were caught in nets and released after instrumentation. We compared data for periods with and without sound disturbance, and with different distances to the sound source.

Our analyses demonstrated a decrease in feeding rate, changes in diving depth profiles, and a paradoxical decrease in heart rate while stroking rate increased during escape. Two general behavioral responses to noise disturbance were identified. One reaction was to "freeze" and remain at the upper part of the water column and significantly reduce the vocalization activity compared to the undisturbed situation. The second reaction was a flight response where the whale increased its swim speed and stroking rate while remaining near the water surface. Here the narwhal altered its vocal activity to only include calls, which were increased significantly.

These behavioral results integrated together with direct measurements of physiological responses enable quantification of the energetic costs related to sound disturbances. In the most extreme case, energetic cost based on changes in stroke frequency for a 100-200 m dive increased three-fold during escape compared to periods without sound disturbance. Together, these results can be used to assess both short-term and long-term effects of seismic activity on narwhals representing individual to population scale effects. Ultimately, these results provide important insights about narwhal vulnerability to anthropogenic noise that can be used to mitigate the effects of human activities in the Arctic.

The Growing Important Marine Mammal Areas (IMMAs) Network: An update on the global process for informing the management practices of marine mammal place-based conservation.

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Important Marine Mammal Areas (IMMAs) are a place-based conservation tool identifying discrete portions of habitat, important for one or more marine mammal species, that have the potential to be delineated and managed for conservation. The IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force (MMPATF) is working to identify a global IMMA Network, through a series of regional expert workshops. During 2016-2019, six expert workshops were held investigating portions of the Pacific, Indian, Atlantic, and Southern Oceans, as well as adjoining South Asian, Mediterranean, and Arabian Seas. Over 100 IMMAs have been identified as a result of these expert workshops, engaging over 200 experts worldwide, assessing candidate IMMAs for over 40 species of marine mammal including cetaceans, pinnipeds and sirenians. Two further workshops are planned for the waters of Australia and New Zealand, and the Eastern and Southeast Temperate and Tropical Pacific. Each regional workshop follows a pre-defined process, in consultation with the marine mammal science and conservation community, developing a range of knowledge products for use by marine researchers, managers, and decision makers. These include a spatially explicit IMMA layer displayed in a web-accessible IMMA e-Atlas and region-specific best practice examples in area-based conservation and management, associated with pilot implementation projects. The products of these workshops are being utilised by regional Task Force groups, part of the legacy of the IMMA workshops, helping ensure the effective use and future evaluation of IMMAs. Examples of IMMA use include those by international conservation and management initiatives, such as the Convention on Migratory Species, Convention on Biological Diversity, and the International Whaling Commission. New case studies are in development for the use of IMMAs to enhance the consideration of marine mammals in protected area networks and to assist with marine spatial planning.

Review of current underwater sound propagation modeling methods

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The understanding of anthropogenic effects on marine life continues to improve. However, the ability to predict an effect will always be limited by the ability to predict the sound field. The goal of the study was to identify the best combination of underwater acoustic models for use by the Exploration and Production (E&P) industry for environmental evaluation and marine animal disturbance mitigation. This goal has been accomplished by providing comprehensive critical and objective analysis of 28 of the currently available underwater acoustic propagation models, application models, and the required supporting data (marine physical and marine animal databases). An important result of achieving this goal is the ability to identify gaps and weaknesses in propagation modeling, databases and exposure modeling.

A brief theoretical summary of the standard numerical models (Wavenumber integration, Normal Modes, Ray Solutions, Marching Solutions, Energy Flux, Hybrid, and Gridded) has been developed. Each of these classes of models is evaluated with respect to differing environmental conditions and model capabilities. Finally, model prediction uncertainties have been analyzed with identification of limiting fidelity factors such as limited oceanographic and seabed knowledge.

Using nonlinear signal processing to identify North Pacific Right Whale sounds and measure calling depths in the Bering Sea

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North Pacific right whales (NPRW) are a highly endangered species that resides in the Bering Sea during summer months, but their winter distribution remains relatively unknown. Substantial amounts of passive acoustic data recorded over the past decade in the Bering Sea have demonstrated the ability to detect the presence of NPRW via two types of calls: a frequency-modulated 'upcall' and an impulsive 'gunshot'. Unfortunately, the structure of these calls can be similar to the calls of much more common species, such as gunshots of bowhead whales and frequency-modulated sweeps of humpback whales, which makes identifying NPRW presence in certain regions difficult during certain times of year. Here we use recently-developed nonlinear signal processing techniques to demonstrate how single-hydrophone recordings of sounds in the Bering embed information that can be used to estimate the range and depth of calls. We investigate whether the depth distribution of calls differs between species, providing a potential cue for species identification. 12 NPRW 'upcalls' and 20 'gunshots', recorded in critical NPRW habitat, were processed to isolate individual normal mode arrivals from each call. The relative modal arrival times permitted range estimates between 1 and 40 km, while the relative modal amplitudes permitted call depth estimates, provided that environmental inversions were obtained from high signal-to-noise ratio calls. Gunshot sounds were generally only produced at a few meters depth, while upcall depths clustered between 10 and 25 m, depth ranges significantly different from gunshots (Wilcoxon rank sum test $p=2.9\text{x}10^{-5}$) and consistent with previously published bioacoustic tagging results from North Atlantic right whales. Bowhead whale gunshot sounds are generated at depths of 20 meters or greater, providing support for the idea that measuring relative calling depths of calls (measuring the relative amplitudes of first and second mode arrivals) may help classify species from otherwise ambiguous frequency-modulated calls. (Work sponsored by the North Pacific Research Board).

Can we help you with your distance sampling survey design or analysis?

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Distance sampling is a widely-used suite of survey methods for estimating population size or

density. For marine mammals, the most common variant is a visual line transect survey, either from an aeroplane or a boat; however, new survey platforms are starting to emerge including aerial photography and video, towed and fixed passive acoustic arrays. Obtaining reliable estimates can be tricky: survey design, field methods and analysis all need to ensure the important assumptions are met as well as possible, and an adequate sample size of lines and of observations are required. Sometimes more complex survey and analysis methods can be used where assumptions of the more basic methods are not met – for example a double-observer protocol can be followed where animals on the trackline are not detected with certainty. The purpose of this poster is twofold. First, we will give an overview of the methods, tools and training available both for the basic approaches and for more complex and recent variants. We will cover recent developments in density surface modelling, estimation of trackline detection probability and incorporation of animal movement. We will showcase recent software for checking survey designs through simulation. Second, we will provide free consultancy to anyone who has questions about surveys they are planning or have already undertaken. Please come see us at the poster, or contact any of us by email (len.thomas, tiago.marques or cso2 @st-andrews.ac.uk; rocio.prieto.gonzalez@gmail.com) to set up a meeting.

Eliminating risk of entanglement in fishing pot lines for large whales: Update on efforts to develop and test "ropeless" gear.

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In the United States and Canada, the entanglement of large whales in buoy lines used in trap/pot fisheries has become a serious problem for several marine mammals and fisheries. In the case of the North Atlantic right whale (*Eubalaena glacialis*) entanglement is the most immediate threat to its persistence. Whales unable to escape entanglement drown or eventually succumb to injuries caused by the lines cutting into and through their tissues, or loss of energy and condition due to drag and/or impaired feeding. Even if they are able to eventually shed the gear, the loss of body condition may impair reproduction for several years. While dozens of mitigation measures have been proposed, many tested, and some implemented over the years, most do not offer a complete or in some cases even a partial solution to the problem. Removing buoy lines from the water is the only approach with the potential to largely eliminate entanglement risk. One such approach entails using so-called "ropeless" gear. Some prototype ropeless gear is designed to bring pots to the surface using inflatable bags, while most have a float or floats that can release a hauling line using a digital timer, galvanic release, or acoustic release so that the traps/pots can be retrieved. This presentation will review the devices currently used and under development, describe the systems necessary to put them into widespread practice, and discuss the hurdles that need to be cleared if this technology is to become operational.

A fine-scale and longitudinal assessment of energy requirements for Arctic seals

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Ice-dependent Arctic seals use sea ice as a substrate for various critical functions including rest, pupping, molting, and predator avoidance. These activities may become disrupted or more energetically costly in the absence of sea ice. For example, during the annual molt seals shed several layers of epidermis and fur, and regenerate a new coat. To facilitate this process, seals haul out for extended periods, increase blood flow to the skin, and maintain elevated skin temperatures. Molting is energetically costly, and associated costs are predicted to increase if appropriate haul-out substrate is unavailable. Similarly, energetic costs may increase if haul out platforms and foraging areas are spatially separated. Measures of resting metabolism can be used to evaluate the potential impact of environmental changes on seasonal energy requirements. Working with eight highly trained Arctic seals, encompassing three species [bearded (*Erignathus barbatus*), ringed (*Pusa hispida*), and spotted (*Phoca largha*) seals], we used open-flow respirometry to track fine-scale changes in the resting metabolic rate (RMR) of individual seals for up to three years. Further, we examined the relative importance of key variables such as air and water temperature, photoperiod, age, body condition, and physiological state on documented changes in RMR. Our data reveal clear seasonal patterns in energy demands that relate to the molting strategies of each species. For species

that molt over a relatively short interval (spotted: 36±4.6 days, ringed: 29±2.5 days), RMR increased sharply (range: 26-47%) across the molt. In contrast, molting over a longer interval (bearded: 107±14.8 days) appeared to limit energetic costs as indicated by a more stable annual RMR. Our findings reveal a previously unknown relationship between molting strategy and seasonal energy requirements and provide quantitative data that can be used to predict how sea ice loss and associated environmental changes may alter energetic balance in Arctic seals.

The status of harbour seals (Phoca vitulina) in the United Kingdom: Regional trends and potential drivers.

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UK harbour seals share their shallow, marine habitat with increasing levels of industrial activity and rapidly changing populations of competing species such as grey seals (Halichoerus grypus). Intensity of these pressures varies regionally and understanding how harbour seal populations have responded to them, at appropriate spatial and temporal scales, is essential for developing effective conservation/management strategies.

Aerial survey counts of seals hauled-out during their annual moult were used to estimate population sizes and trends at national (UK), regional (Seal Management Unit; SMU) and local (Special Area of Conservation; SAC) scales.

The current UK harbour seal population estimate is similar to estimates from the 1990s, but some sub-populations have declined significantly while others have increased. Fitted trends suggest that UK harbour seal populations are divided into three geographically coherent groups: Southeast populations (Northeast & Southeast English SMUs) showed continuous increases punctuated by PDV epidemics in 1988 and 2002; Northeast populations (East-Scotland, Moray-Firth, Orkney, Shetland SMUs) have declined dramatically since the late 1990s; Northwest populations (West-Scotland, Western-Isles, Southwest-Scotland SMUs) have remained stable or increased. This geographical population substructure is matched by recent population genetics results.

Trends within SACs generally match SMU trends since the 2002 PDV epidemic. Of nine harbour seal SACs, four declined (in East-Scotland, Moray-Firth and Orkney SMUs), four remained stable (in Shetland and West-Scotland SMUs), and one increased (in Southeast England SMU).

Differences in regional trends have resulted in large changes in relative abundance: e.g. in 1996-1997 West-Scotland and Orkney each held c.27% of the UK population but now hold c.50% and c.4% respectively; in 1980, the Southeast England population was c50% that of the Wadden Sea but by 2016 was <20%. Regional grey seal trends are presented and grey seal competition and/or predation are discussed as potential drivers of regional harbour seal dynamics.

Beyond hormones: Gaining the most physiological data from blow sampling using shotgun proteomics.

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Collection of blow (exhaled breath condensate) has become a promising alternative to blood for obtaining biological information such as hormones, microbiome and genetics from free ranging cetaceans. Additional information may also be gained from other proteins expired in the breath. Qubit protein analysis of 72 blow samples from 10 belugas (*Delphinapterus leucas*) suggests variable concentrations ranging from <100 to >7,000 µg/ml. Identification and quantification of the blow proteome may be useful in determining lung health, as well as physiological status. This project aims to investigate the application of blow for this purpose by evaluating how the protein profile in beluga blow samples correlates with matched blood samples, and identifying changes in the proteome that may be associated with dive physiology. Three sets of matched blood and blow samples were collected from two belugas (1 male, 1 female) at Mystic Aquarium. In addition, matched blood and blow samples were collected from a single whale following completion of either active or stationary dives (2 replicates). Blow samples were also collected immediately prior to and 1 hour following these dive behaviors, demonstrating the usefulness of blow as a non-invasive tool for repeated sampling. While results of this work are forthcoming, a mid-level protein profile analysis was carried out on a single pooled blow sample

submitted to MS Bioworks. Only 10 µg of protein was needed, and over 482 proteins were identified. Among the most abundant proteins were serum albumin, mucin, cytokeratins and several complement proteins, important mediators of inflammatory responses. It is expected that blood and blow protein profiles will be similar though not exact due to perfusion and protein transport processes. We aim to identify specific proteins with altered abundance following breath-hold (dives) with and without activity, which can be further used to understand the health status of free ranging whales.

Simulating humpback whales response to airgun sounds using agent based models

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The behavioral response of marine mammals to high intensity sounds such as airguns can occur at relatively large ranges. Yet, it has been a challenge to understand the population level consequences of these effects. Predictive modelling is often the only available approach for quantifying movement patterns in response to pressures such as noise to inform population studies. The use of models rests on the assumption that they are able to replicate natural conditions, which has not been proven sufficiently. Here, we investigated the ability of Agent Based Models (ABM) to imitate the movement of migrating humpback whales (*Megaptera novaengliae*). The agents were released into a simulated domain, where their decisions were generated stochastically (i.e. within predefined probabilities) based on coded traits and established external forcings such as temperature and noise. The input data for the ABM came from the BRAHSS study (Behavioral Response of Australian Humpback whales to Seismic Surveys). The model was run for baseline and sound exposure scenarios. Various output measures were compared between the BRAHSS and the ABM data. Swimming speed, course changes and deviations from course were all simulated in a way that did not show any significant differences to the observations during BRAHSS. Only for diving time, our model showed differences to observations. This can be explained by the lack of model calibration for this factor. Our study confirms the potential of ABM to replicate movements of marine mammals in both natural and sound impacted circumstances. We found the ABM successfully imitate key migratory behaviors observed during the BRAHSS experiments as well as changes in these behaviors when agents were exposed to a moving airgun sound source. While the ABM of migrating humpback whales does reflect most humpback behaviors observed in the BRAHSS study, knowledge gaps call for further dedicated research related to ABM modelling.

Identifying diel variation in Northern Resident killer whale vocal activity, call type and temporal frequency of echolocation using digital acoustic recordings from DTAGs.

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The fish-eating Northern Resident killer whale (NRKW) population frequents waters from southern Alaska to northern Washington state, with seasonal movements throughout the Pacific Canadian waters that correspond to the presence of their primary prey species, which include Chinook and other large salmonids. Bouts of fast repetitive clicks with short inter-click intervals (termed "buzzes") employed during the terminal phase of prey pursuit are strongly associated with prey capture attempts. Use of echolocation to identify and secure prey is a vital component of the life history of this ecotype and communication between individuals during foraging contributes to prey sharing success. Reduction in foraging efficiency may occur when animals are exposed to anthropogenic noise from vessel traffic, which masks communication or echolocation signals. Suction cup digital acoustic recording tags (DTAGs) were deployed on NRKW in Johnstone Strait to evaluate night time foraging behaviour and guide mitigation of impacts from vessel traffic on killer whale foraging and catch success. In August of 2018 (year one of a three year study), 18 individual whales were tagged, resulting in 35 hours of day and 35 hours of night time data. Vocal activity, call type and echolocation use were quantified and compared from day to night. NRKW also engage in a behaviour called "beach rubbing", where they rub their bodies on stones in the shallow waters of beaches. Contact with the pebbles results in a distinctive sound signature and provides an opportunity to examine the diel pattern of rubbing beach use. These analyses contribute

important information on NRKW behaviour and we discuss the results with respect to diel differences in shipping traffic and how the potential impacts of vessel noise differ between day and night.

Diversity of endogenous carbon monoxide (CO) in the blood of 24 air-breathing diving vertebrates

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Carbon monoxide (CO) is considered by many to be strictly a toxic gas. However, CO is naturally produced in bacteria, plants, and animals from the natural breakdown of heme, a common component of many heme-proteins used for oxygen transport and storage. We recently discovered that an animal with extremely high heme stores, the northern elephant seal, have concentrations of CO in their blood that resemble the levels seen in chronic cigarette smokers. We hypothesize that the elevated CO seen in the blood of elephant seals is directly related to their heme protein store concentration, and not solely attributable to the fact they are an air-breathing diver. To test this, we have measured the concentrations of CO in the blood of 24 air-breathing vertebrate divers (pinnipeds, cetaceans, mustelids, penguins, and sea turtles) with a wide variation in their heme protein stores. We find that heme stores alone do not predict the magnitude of CO seen in the blood of animals, as we measured higher levels of CO in species with the highest heme protein stores (e.g., elephant seals) as well as in the species with the lowest heme proteins stores (e.g., sea turtles). We suggest the variability in endogenous CO seen between the taxa could better be reflected by the rate of red blood cell turnover, or average breath-hold duration.

Using fine-scale variation in habitat features and environmental productivity to estimate local carrying capacity and range-wide recovery potential for Southern sea otters

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For many depleted marine mammal species, managers face challenging questions about recovery potential: for example, what habitats can support sustainable populations, and how to set recovery targets given uncertainty about future abundance? One approach used to answer these questions is to extrapolate densities from existing populations that have already reached equilibrium; however, for species that have been severely depleted and are still recovering there may be few such populations to work with. Moreover, habitat characteristics of still-unoccupied areas may differ from the few areas in which populations have fully recovered. We present a multi-scale analytical framework for circumventing both challenges, simultaneously answering questions of habitat suitability and population recovery potential. We use Bayesian State-Space methods to fit a density-dependent process model to 35-years of spatially-explicit survey data from recovering southern sea otter populations. Localized carrying capacity (K) is computed at the scale of a 100m spatial grid as a multivariate function of both abiotic (bathymetry, benthic substrate type and distance from shore) and biotic (kelp abundance, nearshore primary productivity) habitat features. The process model also incorporates population spatial structure, environmental stochasticity and key sources of density-independent mortality (the latter were fit to cause-of-death data from beach-cast carcasses). Our approach allows estimation of K from survey time series even in areas still below equilibrium abundance and provides realistic estimates of K across the full range of variation in habitat characteristics, with associated precision estimates accounting for both process error and parameter uncertainty. We next apply posterior predictive distributions from the fitted model to estimate recovery potential in currently unoccupied areas of the historical range in California. We use our results to identify important habitat areas for future

colonization and recovery, and to provide a robust estimate of range-wide recovery potential that can be used by managers to determine the Optimum Sustainable Population (OSP) target abundance for southern sea otters.

Differences in humpback whale food preferences during two summer seasons in Senyavin Strait, Chukotka: Behavioral evidence.

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Humpback whales are known to feed on a wide variety of prey, with their spatial distribution strongly dependent on abundance and density of prey aggregations during the feeding season. Various methods, some more invasive than others, are used to identify the prey — parallel fish trawling, isotope analysis, stomach studies. It is important to develop methods to identify prey which could be used in critical habitats without disturbing the whales. Here we suggest a method to determine the predominant prey by whale behavior and supplementary observations with control by stable isotope analysis. Small-boat surveys were conducted during August-September 2017 and 2018 in Senyavin Strait, Chukotka, to collect humpback whale behavioral data, tissue samples and photo-identification. A total of 34 days at sea resulted in identification of 143 individual whales. The spatial distribution of feeding humpbacks changed dramatically between seasons. In 2017 whales foraged over depths of 20-60 m with more activity in daytime and often accompanied by seabirds. In 2018 all the whales moved north to a deeper bay, where they were mostly resting in daytime and foraging in the evenings with no birds around. In addition, the faeces samples taken opportunistically in 2018 revealed the presence of krill (Euphausiacea) mandibles. The stable isotope analysis showed a higher trophic level for 2017 ($p<0.05$). Thus we conclude that, in general, humpback whales switched their diet from schooling fish in 2017 to krill in 2018. Our data provide an idea not only about the feeding ecology of a humpback whale aggregation, but also about the underlying prey distribution and ecosystem processes. The study was supported by the Russian Foundation for Basic Research, grant 18-04-00462.

Assessment of ship strike risk for sperm whales, using prey-informed distribution models and shipping intensity from AIS

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Mortality or serious injuries to whales from ship strikes have been reported worldwide, and currently are one of the major threats to some whale populations. In the Azores, sperm whale injury and mortality rate from ship strikes is unknown, but several episodes were recorded over the years, calling for a better understanding of the risk posed by this threat to the whales.

To address that question, we modelled sperm whale distribution in the Azores for the spring, summer and autumn, using static and dynamic environmental predictors. Predictors included prey (micronekton) distributions simulated with the Spatial Ecosystem and Population Dynamics Model (SEAPODYM), as previous studies have shown that prey information can greatly improve model performance. Whale sightings were recorded by observers from the Azores Fisheries Observer Program (POPA), between 2001-2015. Shipping intensity was calculated from data collected between 2012-2015 using the automatic identification system (AIS), on-board most commercial, fishing and passenger vessels. Areas of greater risk of ship strikes were identified by intersecting predicted whale distribution and shipping routes.

Several shipping routes were identified, corresponding chiefly to passenger and cargo lines between the islands, large cargo ships and tankers crossing the region, and routes between the main fishing ports and fishing grounds.

Mean predicted relative sperm whale density varied among seasons, although some areas consistently had some of the highest values within a season. Accordingly, areas of greater ship strike risk also varied seasonally. In all seasons there was an overlap between areas with higher predicted relative sperm whale densities and intense shipping routes. However, the risk of ship strikes appears to be greater during the spring, when the highest predicted whale density values were calculated. These results will be instrumental to develop management tools to decrease ship strike risk to sperm whales in the region.

Advancing anthropogenic noise risk and noise mitigation assessments for endangered Southern Resident Killer Whales

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Endangered Southern Resident Killer Whales (SRKW) number only 75 individuals. Synergistic threats of lowered prey availability, noise disturbance from whale watching boats and large ships, and high-levels of contaminants all have been documented to hinder recovery. Unprecedented levels of concern about the population's future has led to multiple research collaborations; here we focus on new approaches that aim to quantify risk from anthropogenic noise and report key findings of four interlinked studies. Firstly, an effort-corrected fine-scale habitat density model (monthly and by pod) using a variety of sightings data sets from 10+ years was developed. Secondly, multiple years of acoustic recordings in Haro Strait using calibrated, cabled, broadband (10Hz-100kHz) hydrophones have provided a better understanding of natural and anthropogenic noise contributors (especially commercial ships), as well as SRKW behaviour. New noise effect metrics that combined disturbance dose-response curves with high-frequency masking in a probabilistic spatiotemporal simulation model have been used to quantify the potential effects of noise disturbance on SRKW foraging. Acoustic sound pressure level analysis using cumulative probability distributions functions and GAMMs and this bespoke SRKW-noise overlap simulation model have been standardized tools used to assess the efficacy of regional mitigation actions, such as 61-day (2017) and 111-day (2018) voluntary commercial vessel slowdown initiatives in Haro Strait, a core area of SRKW Critical Habitat. A better understanding of key foraging areas is vital for population recovery, especially in offshore areas where habitat use may be changing, as well as for defining marine protected areas. While challenges remain, political will has intensified trans-boundary stakeholders to advance a suite of mitigation actions, to enhance eduction and fill key data gaps. The studies reported here assist in defining where, when and what mitigation actions managers should consider in protecting SRKW, as well as highlighting steps needed to improve future noise risk assessments.

Auto-detection of gray whales (Eschrichtius robustus) off Sakhalin Island, Russia using shore-based infrared

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In 2017, a 28 km^2 section of the gray whale (*Eschrichtius robustus)* Sakhalin nearshore feeding area at the mouth of Piltun Bay, Russia, was monitored for more than three months using a shore-based infrared, automated whale detection system (WDS). The WDS was comprised of nine thermal cameras that covered a 90° field of view (FOV) and displayed whale blows on screen for real-time viewing during the day or night. Long-wave infrared (LWIR) video data were collected 24 hours/day, 7 days a week for a total of 98 days (May 28-Sept 3), resulting in 54,493 whale blows detected by the LWIR WDS. Effective detection distance for the WDS was up to 6km from the platform, and the average whale distance was 1.66km. Detections occurred at all hours of the day and night, and on average, 30-70 blows were detected hourly over the period. The average hourly number of blows were lowest from late morning to midday (0900-1300) and peaked late afternoon to early morning (1600-0200). As expected from historical distribution studies of the area, the maximum number of detections occurred in July when mothers return to the area with their calves. Dense fog prevented detections, but whale blows

were detected by the WDS during some periods of light fog, rain and high sea state (

Visual assessments of skin lesions on free-ranging bottlenose dolphins (Tursiops truncatus); Reliability and utility of quantitative tools.

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Skin lesion prevalence in a cetacean population can serve as an indicator of population health. Photo analyses offer a simple, non-invasive approach to characterizing and quantifying skin lesions in cetaceans. In many cases, photos may be the only data available from which to gain insight on health concerns for a given wild population. However, there are limitations to using photos and there's subjectivity in classifying skin lesion types and/or quantifying measures of skin lesion prevalence and extent. One needs to ensure that measures used are reliable (*i.e.*, that there is consistency in the results of a measure) otherwise the validity of results is questionable and may mislead interpretation. This is a commonly overlooked concern in the literature, where scoring photo data is commonly executed by a single person and not tested for reliability.

We used data from photo-identification studies of common bottlenose dolphins (*Tursiops truncatus*) in the U.S. Northern Gulf of Mexico to: (1) test the reliability of a skin lesion classification system, (2) compare methods of quantifying skin lesion extent, and (3) determine the validity of using the dorsal fin as a proxy for assessing skin lesions on the entire visible dorsal/lateral surface. Good to strong levels of reliability were achieved for seven of 17 defined lesion types (categorized by appearance and/or known etiology) and reliability was high for the two tested measures of extent of skin coverage (tracing tool vs. rating approach). Skin lesion extent estimated from the dorsal fin alone over- or under- represented the visible dorsal/lateral surface by as much as 43%, suggesting that this is an unreliable proxy for the entire animal. This study provides a much-needed context analysis of tools used for quantifying skin lesions in dolphins. We discuss the pros and cons of the methods tested and provide recommendations for future studies.

Genetic investigation on Cuvier's beaked whale, Ziphius cavirostris on the coast of Turkey and Northern Cyprus, based on mtDNA sequences.

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The beaked whales are the least known cetacean taxa in the world and mostly known through stranding records in the world oceans. Cuvier's beaked whale *Ziphius cavirostris* is the only beaked whale species commonly found in the Mediterranean Sea, but their distribution is cosmopolitan the northern hemisphere. They are known to be sensitive to noise pollution, indicated by stranding cases due to seisimic surveys or naval operations using mid-frequency sonar. Their genetic structure has little been studied due to the lack of samples. Five strandings of Cuvier's beaked whale were reported along the coast of Turkey and northern Cyprus in June 2016 and March, November 2017. In this first genetic study on the Cuvier's beaked whales from the Aegean Sea and the Levantine Sea, undertaken with these stranded samples, mitochondrial DNA control region (444 bp) and cytochrome b (424 bp) sequences revealed two haplotypes (four out of five individuals had a single haplotype). Control region haplotypes were identical to two previously identified ones from the Ionian (Greece) and Adriatic (Croatia) Seas, the only areas previously investigated within the Mediterranean basin. The isolated eastern Mediterranean subpopulation was highly differentiated based upon the presence of two unique haplotypes, which were not found outside of the Mediterranean. More samples from the Mediterranean Sea (especially the western basin) need to be sequenced with the same mtDNA markers for a better understanding of the genetic population structure of this species, which can be used to elaborate more concrete conservation measures for this species.

Prey echoes reveal long range biosonar behaviour in sperm whales.
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Sperm whales use their hypertrophied nasal complex to produce the most energetic sounds in the animal kingdom supposedly to echolocate deep-sea prey at long ranges. However, direct tests of this long-standing hypothesis are lacking, and little is known about how sperm whales use this high-powered biosonar system to forage. To test how their self-generated, large scale acoustic scenes guide their foraging and biosonar behavior, we deployed sound and movement tags (DTAG4) on the anterior part of the nose of three sperm whales. For all three whales, we recorded bottom and surface echoes, and for one of them, we were able to record individual prey echoes out to ranges of 100 meters during 22 foraging dives. That whale encountered between 79 and 473 echoic objects per foraging dive of which less than 10% were targeted for capture, as inferred by the presence of a buzz, suggesting echo-informed prey selection. Echoes from some of the targeted prey could be detected throughout the transition from regular clicking to the buzz phase, revealing a hand off distance to this fast tracking mode of echolocation of some 25 meters, surprisingly long compared to other toothed whales. None of the three, tagged sperm whales consistently reduced interclick interval or click intensity leading up to buzzes as would be expected if tracking a single target. Rather, acoustic gaze changes appeared to be driven by echo returns from the sea floor and possibly the large-scale auditory scene of the deep scattering layer. In conclusion, we provide direct evidence that their powerful sound generating nose equips sperm whales to echolocate prey resources over long ranges and as a consequence acoustic gaze changes may be driven primarily by the large scale acoustic scene rather than by the spatio-temporal relationship with individual prey.

Evolutionary consequences of the structure-function relationship of the pinniped ankle during secondary adaptation to life in water.
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To reveal morphological changes in the structure-function relationship of the pinniped ankle bones during secondary adaptation to life in water, I traced the character change of the pinniped astragalus and calcaneum.

The results reveal that the otariid astragalus and calcaneum possess the greatest number of primitive characters in the crown pinnipeds. Due to their swimming locomotion using only forelimbs, the primitive ankle joint remains in the crown pinnipeds because their ankle joints have no functional requirement from swimming locomotion. The Odobeninae (Odobenidae) and *Allodesmus* spp. (Desmatophocidae) share many characters in their ankle bones, which suggests that the function of their ankle joints also is similar. Previous studies based on axial morphology suggested that *Odobenus rosmarus* (Odobeninae) and *Allodesmus* spp. shared the same swimming style, and my study supports this suggestion. Some previous studies indicated the correlation between the prosperity of the crown odobenids (i.e., Dusignathinae + Odobeninae) and the decline of *Allodesmus* spp. during Tortonian (mid to late Miocene). The results of my study suggest a possibility of the correlation between the replacement of their niche and an inferred similarity of their ankle joints. The phocids possess a specialized ankle joint. Some unique characters indicate the ankle joint of the phocids is twisted laterally, and allowing flexibility and strong plantar flexion. Because of the "twisted" ankle, in the phocids, the hindlimb did not contribute to movement on land. On the other hand, this ankle is adaptive for their swimming: lateral pelvic oscillation. This is the functional trade-off for dual locomotion: walking and swimming. Moreover, in the pinnipeds with a swimming style defined by lateral pelvic oscillation, the phocids achieved the greatest species diversity, geographic distribution, and feeding diversity. Therefore, I suggest that phocid's acquisition of the specialized ankle led to their divergence in the pinnipeds of the same swimming style.

Calving during migration: Recovering humpback whales giving birth in unprotected waters.
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Humpback whales (*Megaptera novaeangliae*) migrate to find suitable calving habitat, which includes warm (19-28°C), shallow, and sheltered waters. East Australian humpback whales (E1) are thought to breed within the vast Great Barrier Reef Region (16°S to 24°S).

Here, we investigated the presence of newborn calves occurring in Gold Coast Bay (i.e. south of the primary breeding grounds) from 2013 and 2016 using platforms of opportunity and a citizen science approach. More specifically, we examined (1) initial location at which newborn calves were observed, (2) depth (m) and SST (°C) associated with these sightings, (3) relative age classification of newborns, and (4) newborn swimming direction via GPS tracking.

A total of 74 newborn calves were observed with photographs and GPS locations recorded. Sightings occurred primarily in July (51.4%), August (41.9%), but also in June (4.1%), and September (2.1%). Based on diagnostic morphological features, newborn calves were categorized as Age Class 1 (n = 30) or Age Class 2 (n = 44).

Results indicated that 1) E1 humpback whales are giving birth during their northern migration, at least 1,000 km south of the primary recognised calving grounds; and that 2) the Gold Coast Bay provides suitable calving habitat (i.e. warm (19.6 to 22.8 C) and shallow (17.2 to 50.8 m)) waters for pregnant humpback whales; and that 3) the majority of newborn Age Class 1 or 2 calves travelled in a northward direction.

We conclude that newborn humpback whale calves are present in the Gold Coast Bay from June until September. Our findings may signify that this population is expanding its calving range to the south, in waters that have no legislative protection or designation as calving areas. Conservation managers and tourism operators should plan appropriate conservation measures to ensure cows with newborn calves can utilise these waters without being affected by anthropogenic activities.

Sounds of stress: Evaluating the relationships between variable soundscapes and gray whale stress hormones.

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Cetaceans live in a sound-filled environment full of acoustic cues to aid foraging, communication and navigation. Human activities often fill the ocean with sounds from vessel traffic and industrial activities, with potential consequences to cetacean ecology and health. Cetaceans may be able to tolerate some degree of added sound, but when does sound become noise? And, when does noise cause stress? We address this knowledge gap through measurement of the soundscape in coastal Oregon, USA waters with spatially and temporally concurrent fecal sample collection from gray whales for hormone analysis. Between June and October 2017 and 2018 we used hydrophones to record 2088 hr of acoustic data at two study sites with contrasting anthropogenic use. To characterize the soundscapes, two bands of acoustic data within the likely hearing range of gray whales were chosen for analysis: a low-frequency (100-150 Hz) band reflected sound associated with larger vessel activity, and a higher-frequency band (2 kHz) reflected smaller vessels and wind generated noise. Median low frequency sound levels were similar at the two sites, yet median higher frequency band levels were up to 7 dB higher at the site with heavy anthropogenic use. Simultaneously, 82 fecal samples were collected and glucocorticoid concentrations were determined after assay validation. Cortisol levels were used as an indicator of physiological stress, and ranged from 0.08 to 68.16 ng/g (mean = 16.36, SD = 12.65). Recognizing that cortisol levels may be affected by intrinsic and extrinsic factors, we used a long-term photo-id dataset, drone body condition assessment, and reproductive hormone levels to control for variation in cortisol levels relative to demographic unit, health, and reproductive status. We then examine the complicated relationships between ocean noise intensity and gray whale stress. This work represents a longitudinal effort to quantify the effect of ocean noise on a wild cetacean.

Chronic exposure to glucocorticoids increases the expression of atrophy-related genes in elephant seal muscle fibers.

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Sustained elevations in circulating glucocorticoids due to chronic or repeated stress can have deleterious consequences for animal health. To study the effects of chronic glucocorticoid exposure on muscle atrophy in elephant seals, we isolated muscle progenitor cells (myoblasts) from three northern elephant seal pups during their molting fast. Elephant seal myoblasts stained positive for the skeletal muscle marker desmin and were fully capable of differentiating into skeletal muscle fibers (myotubes) in primary culture. Differentiation was accompanied by marked increases in the mRNA expression of the myogenic genes *mrf4*, *myogenin*, *myod*, *myh1*, *myh8*, and *tnnt1*. Exposure to increasing concentrations (1-100 μM) of the synthetic glucocorticoid dexamethasone (DEX) for 48h decreased the expression of glucocorticoid receptors *gr1* and *gr2* in a dose-dependent manner, suggesting that prolonged DEX exposure promotes a compensatory response to increased glucocorticoid receptor signaling. Exposure to 1-10 μM DEX increased the expression of myogenic genes (*myogenin* and *myrf4*) and atrogene *murf1* whereas exposure to 100 μM DEX had the opposite effect. Unexpectedly, exposure to DEX had no effect on *mtor* or *pcna* expression suggesting that even when exposed to high doses to glucocorticoids, protein synthesis is not impaired in primary elephant seal myotubes. Conversely, DEX exposure increased the expression of the myostatin regulator *cebpd* and atrogenes *foxo3* and *ddit4* in a dose-dependent manner, suggesting that prolonged exposure to high concentrations of glucocorticoids might promote muscle atrophy in elephant seals despite their extraordinary capacity to tolerate stress.

Presence of fin whale (Balaenoptera physalus) related with coastal influence and oceanographic conditions in Garraf feeding ground

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The fin whale (*Balaenoptera physalus*) moves every spring season through the Catalan coast and the Catalano-Balearic Sea. Since 2014, from March to May, visual maritime surveys consisting of random transects have been conducted and sightings data has been recorded. The study area is a coastal zone of more than 1300 km^2 and extends until 15 miles offshore. The presence and distribution of fin whales in the area has been studied; differences between seasons have been observed in number of animals and their spatial and time distribution. In addition, behavioral data has been collected, having recorded mainly foraging and feeding behavior. For this reason, we aimed to analyze the influence of the coast on the fin whale presence. A comparative study has been done considering the next variables: presence and distribution of fin whales, chlorophyll-a concentration, sea surface temperature (SST) and salinity (SAL), as well as rainfall inputs on land (in a 50 km radius from study area). For the analysis, 8 day and monthly resolution data of oceanographic variables and monthly rainfall inputs have been used. *The rainfall has been related with and increment of phytoplankton; satellite chlorophyll has been used as a proxy of phytoplankton biomass. There is a positive Pearson correlation between rainfall and chlorophyll-a concentration. And a positive non-significant correlation between rainfall and fin whale sightings with an offset of one month. An offset of 2-3 weeks has been found between chlorophyll concentration and whale sightings. Moreover, crosscorrelations show a relationship between the presence of fin whales and the oceanographic variables chlorophyll-a, SST and SAL, and rainfall. Thus, the coastal inputs in this area have a high impact in the presence of fin whales, since less rainfall on land in the previous weeks cause a decrease of the fin whales observed. Enforcing it as a feeding ground.*

Seasonal and geographical occurrence of blue whale stereotyped and non-stereotyped calls in the Southern Indian Ocean.

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The Southern Indian Ocean is a seasonal habitat for the Antarctic blue whale as well as for Madagascan and Australian pygmy blue whale populations. Their presence has been demonstrated by analysing continuous acoustic records from the OHASISBIO hydrophone network. This array, deployed since 2010, comprises 5 to 9 fixed mooring sites spread over a region from 24° to 56° South and from 52°

to 83° East. Antarctic blue whale acoustic occurrence has been well described within this territory, based on a systematic detection of its stereotyped Z-calls. However, pygmy blue whale distribution has mainly been inferred from broad-scale acoustic power spectral density estimations that lack precision. In addition, D-calls, which are non-stereotyped calls produced by males and females of every population while foraging, have never been monitored in detail in the area. To study temporal and geographical occurrence of these four sound types in the OHASISBIO hydroacoustic data, we applied an automated detection algorithm based on dictionary learning and sparse representation of the signal. The systematic detection of stereotyped calls confirms the distribution pattern described for Antarctic blue whales and improves that of pygmy blue whale acoustic populations. Madagascan pygmy blue whale calls are mainly detected west of the network, whereas Australian pygmy blue whales are mostly recorded at the eastern sites. Both populations share a common seasonality, with a detection peak during austral autumn. Overall, these patterns provide a better understanding of blue whale sympatric areas, where multiple sub-species or populations seasonally gather. D-calls are detected all over the hydrophone network, with a variable number of detections depending on the site, year and season. Eventually, the comparison of the detection patterns of stereotyped calls and D-calls in this 9-year-long dataset provides insights on how blue whale populations use and share the Southern Indian Ocean as habitat.

The effect of anthropogenic noise on foraging buzz activity of bottlenose dolphins (Tursiops truncatus) in the New York Bight

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Vessel noise has been shown to interfere with odontocete echolocation. When foraging, bottlenose dolphins produce shorter, faster clicks with shorter inter-click intervals (ICI<16ms), called *foraging buzzes.* Previous studies demonstrate that in heavily trafficked waterways, high vessel noise significantly reduced prey capture attempts in small cetaceans. Bottlenose dolphins are present in New York waters from spring to fall, migrating south during winter. Their more recent and extended presence suggests that the coast of New York provides important foraging habitat. Presently, little is known about the foraging behavior of these dolphins and the potential impact from feeding around the busy New York Harbor. We used passive acoustic monitoring to evaluate dolphin foraging behavior, indicated by foraging buzzes, in high-level and low-level (>96 & <96dB re 1µPa, respectively) anthropogenic noise conditions. Recordings were analyzed from six acoustic recorders deployed over one year in the New York Harbor. A click detector was used to identify all foraging buzzes, and only those with a signal-to-noise ratio of at least 10dB were included in the final analysis. Foraging buzzes were measured by the number of buzz sequences and total duration within each 1-minute segment where these buzzes were detected. A two-sample permutation test was used to test for a significant difference in foraging rates between noise conditions. Foraging activity tended to decrease under high-level noise conditions, even after taking into account masking effects. These results demonstrate a negative relationship likely attributed to anthropogenic noise on the foraging activity of dolphins. Interruption of foraging activity may impact the overall energetic budgets of these dolphins, possibly leading to decreased fitness or other consequences. Further research into the health, diet, and behavior of these dolphins is required to understand the extent to which anthropogenic noise is disrupting foraging and the long-term effects of such disruptions on population dynamics.

Monitoring odontocetes via their clicks: Surprising strengths and weaknesses of high-resoution time-domain data analysis.

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Valuable numerical assessment of the Vaquita and the Baltic Sea Harbor Porpoise (SAMBAH) has been achieved using click loggers. The detections in these studies were based on finding 'coherent' trains of similar clicks in C-POD data. This greatly reduces the false positive rates of click-by-click classifiers but has had a high false negative rate for dolphins.

To improve this 12 different time domain features of each click are recorded by the C-POD-F logger. Multiple descriptors of train coherence are then derived from these time-domain click features, plus click time and measures of click reverberation. Some of these descriptors are then used to choose between alternative possible trains, and others are 'reserved' to avoid the 'overfitting' hazard of using

the same criteria to find trains and to measure their coherence.

To explore and assess the discriminatory power the distributions of these train descriptor values in different types of cetacean-free noise were compared with their values in data dominated by true trains from porpoises, dolphins, boat sonars, or weak unknown train sources (WUTS). The data came from C-POD-F click records, C-POD-F raw data capture, or sound sampled at 586kHz.

The results showed that (1) useful levels of discriminatory power come from time-domain descriptors, (2) this usually varies across noise regimes, (3) recording at high time resolution increases power, (4) reverberation metrics are valuable, (5) power in train coherence assessment is not generally closely related to power in determining the species, (6) post-processing of time-domain data is very fast, but both (7) real time determination of click starts and ends, and (8) useful real-time extraction of very weak broadband clicks are problematic, and (9) that automated population trend monitoring could be improved using this approach.

Geographic variation in Blainville's beaked whale (Mesoplodon densirostris) echolocation signal.

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Blainville's beaked whales (*Mesoplodon densirostris*) have a cosmopolitan distribution from temperate to tropical waters, but are classified as "Data Deficient" under the IUCN Red List. We investigated geographic differences in Blainville's beaked whale frequency-modulated (FM) echolocation pulses from recording sites across the North Pacific, Gulf of Mexico, and NW Atlantic as a potential tool for population-level discrimination. Blainville's beaked whale FM pulses have been described as species-specific, with a steep energy onset at around 25 kHz, a small energy peak at 22 kHz, a peak frequency of 30 to 34 kHz, and an inter-click interval of 280 ms. Quantification of the variability in spectral shapes and inter-click intervals measured within and between encounters was achieved through weighted network clustering. Spectral averages obtained from the primary clusters identified at each site exhibited frequency shifts of up to +/- 6 kHz relative to the previously described Blainville's FM pulse type. We observed differences in spectral structure between ocean basins and also identified a latitudinal cline, with higher peak frequencies occurring in lower latitudes. While geographic variation in click characteristics has been documented for several species of odontocetes, such variation had not been documented previously in beaked whales. The observed variability may have several possible origins, potentially related to differences in body size or prey size. These findings provide insight into the geographic distribution of a rarely observed species, and also suggest that this variability in echolocation signal frequency may be a first indication of acoustic delineation between population-level boundaries of Blainville's beaked whales that have not been identified previously.

Simple models to predict daily prey consumption by marine mammals as a function of their costs of living

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In general, smaller species of marine mammals have higher mass-specific energy requirements than bigger species (e.g., 4-5% for dolphins and 2-3% for large whales). However, closer inspection of energetic requirements of different sized species reveals that many consume significantly more or less than predicted by generalized models of consumption. This implies that the simple models currently used to determine daily rations are ineffective to estimate the food requirements of marine mammals, and that new means are required to yield better estimates of prey consumption. I used well-supported estimates of energy requirements for 28 species of marine mammals to derive three generalized equations that predict the energy requirements of all pinnipeds and cetaceans as a function of body mass and their cost of living (high, medium and low). The relationship between cost of living and food requirements likely reflects

differences in evolutionary pathways that shaped predator-prey interactions. These new equations that incorporate cost of living are superior to existing generalized equations that have been used in the past to estimate energetic needs, and can be used to derive estimates of prey consumption for species of marine mammal with unknown energy requirements.

The trophic interactions among cetaceans in the southwestern Atlantic Ocean inferred through stable isotopes

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The offshore waters in the western South Atlantic sustain large abundances of cetacean species. Yet, due to their occurrence at long distances from the coast hampering the study of their feeding habits, little is known about their intra and inter-specific trophic ecology and level of interactions. We measured carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes in skin biopsies of odontocetes to assess the spatiotemporal variation in their area of isotopic niche and overlap in resource use. The study area in the outer continental shelf and slope off Brazil (~23°S to ~34°S) was divided into southeast and south areas, according to their oceanographic characteristics. $\delta^{13}C$ and $\delta^{15}N$ showed some persistent seasonal (austral autumn vs. spring) and latitudinal patterns, consistent with variations at the base of the local food-web. The rough-toothed (*Steno bredanensis*) and common dolphins (*Delphinus delphis*) had the highest mean $\delta^{15}N$ values, indicating high trophic positions in the food webs of the outer continental shelf and shelf break of the southern region. Bottlenose (*Tursiops truncatus*) and Atlantic spotted dolphins (*Stenella frontalis*), frequently reported forming mixed-species associations in the region, showed large isotopic niche overlap in both seasons and areas. Atlantic spotted and common dolphins showed significantly large core isotopic niche overlap in the South, mainly in spring. Spinner dolphins (*S. longirostris*) showed consistently low $\delta^{15}N$ values, and an overlap in its isotopic niche with the pantropical spotted dolphin (*S. attenuata*) in the southeast region. Killer whales (*Orcinus orca*) and a single pilot whale (*Globicephala melas*) had very similar $\delta^{13}C$ and $\delta^{15}N$ values, consistent with feeding in offshore waters. $\delta^{13}C$ and $\delta^{15}N$ in sperm whales (*Physeter macrocephalus*) suggest individuals feed on similar trophic levels, but throughout a wide spatial range. The data presented here provides a first insight into the trophic interactions and ecological niche of cetaceans in these oceanic waters.

The dynamic time waveforms of Amazon River dolphins (Inia geoffrensis) and other acoustic emanations: Comparisons of free-ranging dolphins in the Peruvian Amazon with a dolphin in human care.

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Documentation of Amazon River dolphin (*Inia geoffrensis*) activity is difficult due to the opaque water in which they commonly inhabit in conjunction with their morphology and shallow-surfacing behavior. Furthermore, obtaining quality audio recordings of these animals is also challenging given their preference for shallow habitats characterized by currents carrying copious quantities of debris, changing bottom topography, and dynamic hydrologic cycles. Recently the IUCN changed the Amazon River dolphin status from data deficient to endangered due to unsustainable fishing practices. However, the quantity of animals found in the wild is still unknown. The goal of this research is to develop methods to acoustically count Amazon River dolphins in their natural habitat. An understanding of the dynamic time waveform is needed to accomplish this goal. To this end, an Amazon River dolphin housed at the Duisburg Zoo in Germany was recorded in March of 2018. This setting allowed investigators to document the location and position of the dolphin in relation to the hydrophone array. This information allowed for the determination of various time waveforms

associated with both on-axis and off-axis clicks. Additionally, comparisons were made between the vocal emanations of the Duisburg Zoo dolphin with those produced by free-ranging dolphins from the Peruvian Amazon. Click peak frequencies obtained from the zoo recordings were lower than those found from Peruvian Amazon recordings. Finally, both zoo dolphin and Peruvian Amazon recordings contained frequency-modulated "whistles", high-amplitude pulses possibly used to stun prey, and suspected Twin Inverted Pulsed Sonar (TWIPS). This work supports the theme of the opening plenary presentation by Roger Payne at the SMM 21st Biennial Conference, illustrating that studies of marine mammals in human care strengthen field studies. Further investigation into the unique high-amplitude pulses is warranted.

Photo identification of marine cetaceans using convolutional neural networks

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Modelling cetacean population dynamics and behaviour is paramount to effective population management and conservation. Cetaceans also make prime candidates for modelling ecosystem change under the ecosystem sentinel concept as they reflect the current state of the environment, responding to changes across different spatial-temporal scales. Methodologies of cetacean research include photo-identification (photo-id) - collecting photographic data and identifying individuals based on unique markings. Manual photo-id can however be costly and time consuming due to the number of person-hours required for identification, as well as the potential for misclassification due to issues such as observer fatigue. Current image analysis software like DARWIN and Wildbook do not employ state-of-the-art deep learning techniques whilst requiring a large amount of manual user input to provide possible matches.

With progressively more data being collected during fieldwork due to an increasing use of technology, there is an urgent need for an automatic system to quickly perform photo-id with reduced error rates. Thus, a novel approach to cetacean photo-id through the utilisation of deep learning networks (specifically Convolutional Neural Networks, CNNs), has been developed and implemented on high-powered GPUs by bringing together an interdisciplinary team of computing scientists, marine biologists, and engineers. This new approach provides a powerful platform for solving fine grain computer vision tasks such as individual animal photo-id.

Images taken during fieldwork are uploaded to the system, which is currently pre-trained to segment *L. albirostris* fins from large panoramic above-water images. The detected fins are passed to a second component for photo-id. Users are then presented with a list of most-likely identifications along with confidence scores, greatly reducing the set of fins a human observer needs to review when matching fins to fin catalogues. This system will significantly aid marine biologists by increasing the accuracy and speed of the identification process.

Assessing the wintering range of Southern Hemisphere humpback whales (Megaptera novaeangliae) using satellite telemetry.

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Satellite tagging provides a wealth of information on movements and habitat use of migratory species, such as baleen whales. Humpback whales typically occur in warm low-latitude waters during winter. Current knowledge suggests that movement (transiting, localized, and migratory) and distribution (clustered or broadly distributed) patterns differ across these wintering grounds; however this has not yet been comprehensively tested. We compare the temporal and spatial low-latitude behavior of humpback whales using a unique tracking dataset of 461 individuals from 2002-2018, representing all three Southern Hemisphere major ocean basins and seven discrete wintering grounds. We applied a switching-state-space model to Argos locations to identify changes in behavioral patterns (i.e. likelihood of exhibiting localized movements). The character of restricted movements differed between regions, with broadly-distributed areas of localized movement along the shelves of continental wintering areas associated with coastal habitat (i.e. eastern and western South Atlantic, eastern Indian Ocean, and eastern South Pacific and Madagascar), contrasted with smaller constrained areas of localized movements near both oceanic islands and offshore shallow bathymetric features (i.e. Oceania and western Indian Ocean islands). Males exhibited localized movement in core areas during the peak of the season in the Western Atlantic and in the Eastern Pacific, as well as in offshore corridors during the southern migration in eastern Indian Ocean. Localized movements of females with calves were observed in different sites across all wintering grounds over the season, which can be used for resting or nursing. Although whales widely disperse across wintering areas, the localized movements revealed a smaller range size of high-use areas. Overall, this comprehensive tracking dataset of Southern Hemisphere humpback whales provides an improved and comparative understanding of their circumglobal wintering behavior and distribution, and also higher resolution information to inform future management measures.

Living with the River dolphins of South America: More than a decade of unlearning and letting go, to conserve across country borders.
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The talk will present, in addition to scientific results, different social, economic and political initiatives that have allowed river dolphins to become a tool for ecosystem conservation of aquatic systems in the Amazon and Orinoquia.

Satellite telemetry in Amazon river dolphins: A regional initiative to evaluate habitat use and movements.
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The Amazon and Orinoco dolphins face a large number of threats, which is reflected in the new categorization of the IUCN as EN. It is critical to determine which are the key (core) areas for these species, the displacements or seasonal migrations, the effect of connectivity loss in several rivers due to dams, and how the dolphins are using protected areas. To evaluate this, a total of 31 dolphins of the genus *Inia* were tagged between 2017 and 2019 in the rivers Tapajós (Brazil), Amazon, Orinoco and Guayabero (Colombia), San Martín (Bolivia) and Marañón (Peru) with Argos-linked Spot 299A satellite transmitters. This study is the first to identify movement patterns and habitat use of *I.g. geoffrensis, I.g. humboldtiana* and *I. boliviensis* using this type of technology in the Amazon and Orinoco. The results show that the largest displacements were performed by *I. boliviensis*, where a male individual moved 333.7 km between

the rivers San Martín and Iténez in Bolivia, followed by an *I.g. geoffrensis* male tagged in the Tapajós River, an *I.g. geoffrensis* female tagged in the Colombian Amazon and finally an *I.g. humboldtiana* (48.8 km). Tagged males were more mobile than females; the latter generally remained in the same areas, with shorter movements between tributaries, lagoons and main rivers. Results show long differential transboundary movements as a result of spatial heterogeneity, water types, system productivity, biomass, and a differential use of habitats. Finally, the importance of the confluences, small tributaries and wetland complexes within the protected areas such as the national and departmental natural parks Juruena (Brazil), Iténez (Bolivia), Pacaya-Samiria (Peru) and Amacayacú and the Tarapoto Ramsar site (Colombia) is highlighted.

An instrument-based aerial survey of ice-associated seals in the Chukchi and East Siberian seas in Russia, spring 2016.

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In the spring of 2016, an instrument-based, multispectral aerial survey was carried out in the Russian part of the Chukchi Sea and eastern part of the East Siberian Sea to estimate the abundance and distribution of ringed and bearded seals on the spring ice. As the distance to the mainland was increasing, the density of both species of seals was statistically significantly declining. According to the statistical modelling results, the highest numbers of ringed seal were expected in the areas located along the coast, where the ice break-up was observed the earliest. Taking into account the correction of the obtained estimates of the abundance of seals on ice to the proportion of animals being disturbed by the aircraft engine noise (30,2% of ringed and 5,9% of bearded seals), and also keeping in mind that up to 32% of the animals could have been in the water during the survey, we expect the population size of the bearded seal in the Russian part of the Chukchi and eastern parts of the East Siberian Sea to exceed 7 000, and the ringed seal - 21 000 individuals. The underestimation can also be attributed to the ringed seal snow lairs being partially untouched in April. This was the first seal instrument-based aerial survey in the region and it provided more verifiable data and robust estimates than previous visual sighting surveys and our analyses took into account more sources of uncertainty, as well. The work was supported by National Marine Fisheries Service, NOAA and NPRB.

Reconstruction of amino acids' carbon and nitrogen stable isotopes profiles in baleen whales earplug

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Phytoplankton plays an important role in marine ecosystems by supporting the marine food web through carbon transfer to higher trophic levels. However, climate change can alter ecological and biogeochemical functions by supporting changes in phytoplankton and species composition. Using carbon and nitrogen stable isotope composition of consumers in higher trophic levels can reveal variation at the base of the food web. Significant advancement in instrumentation and analytical technique offers a powerful tool for tracking the sources of stable isotope variation in consumers and the biochemical pathways. Analysis of compound-specific stable isotope of individual amino acids (CSIA-AAs) using gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS) provides more insight into baseline and trophic variability on the consumer. Baleen whale earplug, traditionally used to provide age estimates and lifespan, has the capability of recording and archiving the life history of individual whales. This novel technique of combining age estimation with reconstructed bulk stable isotope and AAs of earwax can assess changes in marine ecosystems structure and productivity in global scale at decadal time scales. This approach is based on enrichment of stable isotope values of some AAs in organisms in comparison to the food source (trophic and non-essential AAs), and other AAs with similar stable isotopes value to the baseline (source and essential

AAs). Reconstruction of multi-decadal bulk stable isotopes along with amino acids stable isotopes in long-lived migratory animals like baleen whales can provide temporal and spatial variation in the structure of marine ecosystem food webs in response to climate changes.

"Click, click. Who's there?" A quantitative description of long-finned pilot whale echolocation clicks from the North Atlantic.
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The long-finned pilot whale (*Globicephala melas*) is a large member of the ocean dolphin family (*Delphinidae*), distributed through the temperate North Atlantic. Much remains unknown regarding the population dynamics and movement of these whales throughout their home ranges. As an abundant, vocally active cetacean species that produce a variety of acoustic signals, pilot whales are good candidates for passive acoustic monitoring (PAM). However, their echolocation clicks are hard to distinguish from those of other delphinid species due to similarities in spectral content, particularly in the absence of accompanying tonal signals. To address this, we used passive acoustic monitoring to establish detailed quantitative descriptions of pilot whale echolocation clicks, including variations in spectral content as a result of receiver depth. Acoustic encounters were recorded with autonomous instruments deployed at various depths in coastal waters off Cape Breton Island, Nova Scotia (n = 29 recordings), as well as offshore on the Scotian Shelf (n = 25 recordings), the Gully Marine Protected Area (n = 2 recordings), and off the coast of Ireland (n = 1 recording). We found that spectral click parameters (peak and centroid frequencies) decreased with increasing receiver depth, while click duration increased. Overall, click spectra got wider and lost high-frequency inputs at greater depths. These differences are important to take in to consideration during PAM monitoring projects, and may be explained by different sound propagation conditions at the surface versus at depth. It is also possible that pilot whales adjust their clicks based on the surrounding environment or behavioral function. The results of this study, combined with prior published work on the classification of tonal calls, will allow for the development of more accurate pilot whale automated click detectors for PAM, leading to better long-term monitoring, with the goal of understanding this species' acoustic behaviour, habitat use, and population structures.

Emerging interactive digital technologies in cetacean and marine conservation
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Education on cetacean and marine conservation is challenging, as most of the ocean are invisible to the human eye, and marine species and processes are spread over large temporal and spatial scales. Interactive digital technologies have the potential to support learning about the ocean, as, virtually, they can take the learners into the depth of the ocean and help them visualise complex interactions between different marine species over time and space.

In 2014, a 10.8-metre long Omura's whale (*Balaenoptera omurai*) stranded in the Hong Kong waters, with evidence of fishery entanglement. Delegates from the Jockey Club College of Veterinary Medicine and Life Sciences and students from various departments of the City University of Hong Kong (CityU) had taken the lead to deflesh the whole skeleton and preserve it into a specimen. Together with the cooperation with the pioneer cetacean virtopsy project, aiming to provide supplementary or complementary information to conventional necropsy for the biological health and profile investigation of stranded cetaceans, CityU is one of the first institutions worldwide to apply interactive digital technology to create various multimedia products in cetacean and marine conservation, namely virtopsy, 3D surface scanning, photogrammetry and 3D printing, motion graphic, immersive virtual reality, and mobile application.

These technologies require different levels of knowledge, manpower and production time. The use of these technologies in cetacean and marine conservation can make the invisible visible, allowing engagement with and manipulation of the abstract features of the ocean, as well as human interactions and threats to marine species. These technologies provide a field of action where users can experiment, make mistakes, get feedback and try again in ways that are different from paper-based learning activities, and would be demonstrated and displayed in various outreach visits and exhibitions, to increase public empathy for nature and arouse public awareness in conservation and nature.

Diel variation in humpback whale singing activity off Chichi-jima Island, Ogasawara,

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Male humpback whales (*Megaptera novaeangliae*) sing complex songs in their breeding season. To investigate the diel and tidal effects on the behavior of humpback whale singers, we conducted passive acoustic monitoring in the Ogasawara Islands, Japan. The waters of the Ogasawara Islands are one of the breeding grounds for humpback whales of the western North Pacific stock. Two automatic underwater sound monitoring systems (AUSOMS-mini stereo, AquaSound Inc., Japan) were deployed at two stations off the west side of Chichi-jima Island during winter 2016–2018 to monitor phonating whales. 24-hour recordings were continuously conducted for 1–3 months per year. The number of singing whales was acoustically counted every hour by using time difference of arrival of each song at both recorders. The mean number of detected singers in each time of day was calculated and compared with the tidal cycle. In total, 5,015 hours recording data were collected. 0–9 singers per hour were detected (mean ± SD = 3.5 ± 1.5 singers/hour), and they appeared throughout the day. The acoustic occurrence of singing whales was peaked in the early morning and dusk and decreased during the daytime when we used all data; however, the peak time was shifted in connection with the tide type. The mean number of detected singers was less during spring tide periods than during the other periods, and that was more during neap tide periods than during the other periods. Additionally, during spring tide periods, more singers were detected in the high tide time than in the low tide time. Our results suggest that the singing activity of humpback whale singers is influenced by the diel and tidal cycles, or they moved offshore where is outside of the detection range of our recorders during the daytime.

Passive acoustic monitoring shows diurnal and seasonal patterns for Irrawaddy dolphins (Orcaella brevirostris) in Kep, Cambodia.
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Irrawaddy dolphins (*Orcaella brevirostris*) are considered Endangered on the IUCN's Red List of Threatened Species, with marine populations being the subject of relatively little research focus in comparison to their freshwater counterparts. In Cambodia's Kep Archipelago, the species faces threats from a high intensity of Illegal, Unreported and Unregulated (IUU) fishing activities, which leads to bycatch, habitat degradation, and prey depletion. As part of The Cambodian Marine Mammal Conservation Project's activities to support the conservation of this population, innovative Passive Acoustic Monitoring (PAM) techniques were employed to collect baseline data on the population's diel and seasonal activity patterns. A C-POD (Continuous POrpoise Detector) was deployed east of Koh Ach Seh (10°21'31" N, 104°19'22" E) on 23 June 2018, to continuously recorded cetacean clicks between 20 and 160 kHz, produced within a 1km range of the device. A Generalised Linear Model was used to examine the initial six-months of data recordings. Significantly more Detection Positive Minutes (DPM – the minutes within each hour with positive recordings of cetaceans) were recorded in non-daylight hours compared to daylight hours, with the fewest DPM recorded between 08:00 – 15:59. September had the highest number of DPM, compared to any other month, followed by October and November. The diurnal and seasonal activity patterns observed could be explained by prey movements, freshwater inputs or monsoon seasonality. This study is the first of its kind, using long-term PAM techniques to study Irrawaddy dolphins. Results reveal crucial information on the population's temporal and seasonal activity patterns. As local IUU fishing predominantly occurs during non-daylight hours, the study also highlights a vital cause for conservation concern, regarding overlapping spatial and temporal use of the Kep Archipelago by both dolphins and IUU fishing vessels at night. Future research to determine population distribution and ranges, to shape future regional conservation strategies are suggested.

Comparison of salmon predation by harbour seals in estuary and non-estuary habitats in British Columbia, Canada
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In British Columbia (B.C.), harbour seals are thought by some to have caused the decline of Chinook salmon, in turn contributing to the decline of Southern Resident killer whales. Recent harbor seal diet data has been restricted to a few years and has come primarily from scats sampled in estuary habitats near salmon bearing rivers. There is emerging evidence suggesting that only a subset of the total population consumes salmon, and that rates of salmon consumption vary considerably with sampling location, season and year. We sampled ~2000 scats collected at an estuary (Cowichan Bay) and 7 non-estuary sites from spring to fall in the Strait of Georgia. Using a combination of hard part and high-throughput DNA techniques, we determined seals consumed a wide range of prey, with gadids (primarily hake) and forage fish (primarily herring) dominating diets in both habitats (typically >75% of diet). Juvenile salmonids, chinook, and to a lesser extent coho and chum, collectively made up 1.4% (CI = 0.8–2.1%) of the spring diet at non-estuaries and 2.5% (CI = 1.4–3.9%) in Cowichan Bay. The difference is considerable when translated into number of salmon smolts consumed, and indicates smolt predation was 50% higher at the estuary site. Salmon consumption spiked in the fall (primarily returning adult chum salmon), and was higher in Cowichan Bay (35%, CI = 29–40%) than at non-estuary sites (9.1%, CI = 7.3–11.0%). In addition to being highly variable by site and season, rates of salmon consumption can vary significantly between years. Our findings highlight that estuaries should not be used as proxies for non-estuary sites when assessing predation on salmonids and that models estimating seal related mortality should consider differences in diets inside and outside of estuaries, over multiple years.

Using science and governance in establishing habitat conservation measures at the Saguenay–St. Lawrence Marine Park and surrounding waters to favor the recovery of the St. Lawrence beluga population.

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The world's most southerly beluga whale (*Delphinaterus leucas*) population, the endangered St. Lawrence beluga, lives downstream of industrial North America. The main threats to the recovery of the population are exposure to contaminants and to disturbance by intensive navigational activities such as shipping and tourism. The Saguenay-St. Lawrence Marine Park, of which 77% of the territory is designated critical habitat for the beluga population and which also encompasses feeding grounds for a diversity of other whale species, is one of the areas used by marine mammals where marine traffic is most intensive in Canada. Under Parks Canada's Conservation and Restoration Program for species at risk, the marine park team is implementing a habitat conservation project (2017-2022) entitled *Sharing the waters with belugas*. The purpose of the project is to protect and restore the acoustic environment of important habitats for species at risk in the marine park, particularly the beluga, to contribute to their recovery while remaining one of the best places in Canada to observe mammals and to increase public support for marine conservation. To date, two habitats have had their level of protection enhanced: 1) The Baie Sainte-Marguerite (<1% of the marine park territory) where navigation was prohibited as of 2018 and 2) A significant portion of the upper St. Lawrence estuary (44% of the marine park territory) where whale watching activities have been excluded as of 2019. These two habitats are intensively used by female belugas and their young during the summer, and their protection is considered essential to favor the recovery of the population. This presentation will focus on the scientific and governance approach used, the challenges, the measures put in place and the first results of compliance to inspire other marine mammal protected areas in their conservation actions to enhance marine mammal habitat protection.

Managing cumulative effects of multiple stressors on marine mammals.

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Assessing the cumulative effects of multiple stressors is a top priority problem in marine ecology. Environmental assessments of proposed actions often must consider the cumulative effect of the action when added to those of other human activities. Scientists view cumulative effects from the perspective of populations rather than activities, with effects accumulating when organisms are repeatedly exposed to the same or different stressors. Most marine mammals are protected from intentional hunting, but over the last century, global industrialization and population growth have created or increased stressors, including chemical and noise pollution, loss of habitat, and bycatch in fishing, which alone kills hundreds of thousands of marine mammals globally each year. Significant

progress has been made in understanding how marine mammals respond to specific dosages of stressors such as toxins or noise, and these dose-response relationships can be used to predict the impact of stressors on individuals. In some cases, especially where we understand the mechanism of action, we can predict the aggregate impact of repeated exposure to the same kind of stressor. However, we cannot predict how stressors will interact to affect individuals and populations of marine mammals. A 2017 US National Academy of Sciences report defines an interaction between stressors to occur if the dose-response function of one stressor changes when the dosage of another stressor is changed. Interaction between stressors can be investigated by estimating dose-response functions of one stressor at several different dosages of a second stressor which cover the expected range in the future environment. To decide how best to reduce the effects of activities that threaten marine mammals, we need to develop methods to assess how changes in a combination of stressors can best bring populations to a healthy resilient state.

Post-release monitoring of a stranded and rehabilitated short-finned pilot whale (Globicephala macrorhynchus)

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Little is known about the movements and behaviors of pilot whales, due to the expense and logistical challenges of studying these pelagic, deep-diving odontocetes. Stranded whales offer unique opportunities to learn about these species, particularly if they are able to be released. A subadult female short-finned pilot whale (*Globicephala macrorhynchus*) stranded on the NE Gulf of Mexico Florida coast in June 2017, was rehabilitated for 38 days and released off the West Florida Shelf. Post-release monitoring of the individual, "Gale," lasted 32 days using a satellite-linked tag that provided data on location, dive depth, and dive duration. Gale appeared to use ocean currents to facilitate a SE movement around Florida, and then a northward movement along the continental shelf break to the waters off Cape Hatteras, North Carolina. During her travels, Gale received a net positive assistance from ocean currents, especially east of Florida where 57% of her travel distance was congruent with the surface speed and direction of the Gulf Stream. The current-assisted travel contributed in-part to our observation of Gale traveling further (4,152 km) and faster (130 km·day^{-1}) than previously reported for *Globicephala spp.* Gale's dive behavior was typical of other pilot whales, with average dive depths (243 ± 136 m) and durations (7.9 ± 2.2 min) within the range of reported values for *Globicephala spp.* Gale also occupied habitats commonly used by pilot whales, such as the continental shelf break and submarine canyons. Thus, it is likely that Gale was using her natural abilities and skills effectively, and that her movements and behaviors could be considered representative of short-finned pilot whales in the Gulf of Mexico and northwestern Atlantic Ocean. The information presented here contributes to a better understanding of pilot whales, their movements between ocean basins, and to the assessment of rehabilitation and release protocols.

The respiratory physiology of the harp seal (Pagophilus groenlandicus): Total lung capacity, anatomical dead space, and ventilatory response to exercise.

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Size and proportional makeup of the marine mammalian respiratory system are important determinants of lung compression at depth, ventilatory airflow, and effective ventilation. Data on phocid total lung capacity (TLC) and dead space (V_D) are sparse, as are quantitative studies of gas exchange in unrestrained seals. In the harp seal (*Pagophilus groenlandicus*), an abundant pinniped in the northern hemisphere, we have a) determined and modeled TLC and V_D, and b) investigated ventilatory responses to exercise. Sixteen individuals (West-Ice stock; both sexes, newborn–adult, euthanized for unrelated research purposes with permits from Greenland authorities) were used for air and water volumetry of excised lungs ($n_{animals}$=10, $n_{measurements}$=132) and conducting airways, from nose to bronchi ($n_{animals}$=16, $n_{measurements}$=147). The TLC was determined with pressure–volume curves, it was 70 [60–88] mL/kg at 40 cmH_2O transpulmonary pressure. It scaled isometrically with total body mass (slope 1.006; r^2=0.99, log–log linear regression); V_D scaled

slightly allometrically (slope 1.129; r^2=0.97). Total adult V_D (3.1 mL/kg, estimate) was partitioned into 9% nasal, 55% tracheal, and 36% bronchial volume. One juvenile female (59 kg) was trained for voluntary spirometry on land/in water at rest and after standardized physical exercise of varying effort levels. Ventilation (n_{trials}=60, $n_{breaths}$=500+) was substrate-specific; minute volume ($\dot{V}_E$) at rest on land was half that in water. Here, average tidal volume (V_T) at rest was high (26% of $TLC_{predicted}$), but it still doubled after heavy exercise (45–60% of $TLC_{predicted}$), as did $\dot{V}_E$. Respiratory frequency was high (31 min^{-1}) and did not change much with physical activity. The maximum V_T (79% of $TLC_{predicted}$) was comparable to human vital capacity (75–80% of TLC). Conclusions: The proportionally small nasal and large tracheal V_D potentially facilitate pressure equalization and lung collapse at depth, respectively; thus, reducing risks of barotrauma and decompression sickness. Increased ventilation after exercise resulted almost solely from an increase in V_T.

DNA barcoding based identification of fish species in the diet of cetaceans at the South-Western coast of the Black Sea.

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Three small cetacean species: the bottlenose dolphin (*Tursiops truncatus*), the short-beaked common dolphin (*Delphis delphius*), the harbor porpoise (*Phocoena phocoena*) inhabit the waters of the Black Sea. All three are under enormous human-induced pressure: direct hunting until 1983, present day by-catch, over-exploitation of the food base, pollution, habitat modification and disturbance by heavy marine traffic. Although the distribution and movements of dolphins are closely related to their feeding habits, only few researchers on the Turkish coastline conducted studies on the diet of cetaceans. We carried a pilot study on DNA barcoding based analysis of the stomach content of two cetacean species stranded to the coast of south-western region of the Black Sea (Zonguldak, Turkey) in spring 2018. DNA metabarcoding as a high throughput sequencing approach has been proven useful in identification of undigested remains in dolphin stomachs, and is more reliable than traditional diet analysis using morphological identification. We used complete homogenized stomach contents of the short-beaked common dolphins and the harbor porpoises. After DNA extraction, the taxon-specific fragments were amplified and sequenced using universal primers for teleost fishes and invertebrates. The most abundant fish species in the diet of the short-beaked common dolphin, as well as of the harbor porpoise, was the horse mackerel. Our research is the first to provide taxonomic identification of prey species of the Black Sea cetaceans using DNA barcoding.

Molecular biomarkers of stress and immune system function in beluga blow

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Using non-invasive sampling techniques is critical especially for cetaceans as a part of a global concern for marine mammal health, and to support conservation efforts of threatened/endangered species in a changing marine environment. Belugas (*Delphinapterus leucas*), such as those in Cook Inlet, AK are critically endangered and others are on the decline. Analysis of exhaled breath condensate (blow) has been established as a non-invasive method for studying the composition of airway lining fluid with potential to identify immune/inflammation related biomarkers (e.g. cytokines, chemokines, and toll-like receptors). This study investigated molecular biomarkers of health using quantitative PCR (qPCR) on cells recovered from beluga blow for assessment of respiratory and systemic immune function. The feasibility of carrying out sex determination and gene expression measurements in the same blow sample was also investigated. Blow samples were collected into 50ml conical tubes twice weekly before, during and after various stressor events (i.e., hydraulic beluga lift construction, whale transport) and the DNA and RNA were simultaneously extracted. To date, validation of qPCR protocols were successfully carried out for inflammatory markers including cyclooxygenase-2 (COX2), C-C-Motif-Chemokine-Ligand-5 (CCL5), interleukin-8 (IL8); regulatory markers including transforming-growth-factor-beta (TGFb), glucocorticoid-receptor (Nr3c1), and a reference gene (GAPDH). The results demonstrate that both DNA (4-25ng/µl) and RNA (5-350ng/µl) can reliably be obtained, and sex determination and gene expression measurements of 4-7 genes can successfully be carried out in the same blow sample depending on yield. Moreover, pre- and post-blow samples taken during acclimation of the whales to a hydraulic lift resulted in significant increase of COX2 and Nr3c1 genes ($p<0.05$). Since gene expression studies can capture perturbations at the cellular level before clinical symptoms develop, the

proposed method can be utilized as an additional diagnostic and health monitoring tool for belugas under professional care as well as for health assessment studies of wild/free-ranging whales.

Gray whale migratory movements between the western and eastern North Pacific

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Gray whales have traditionally been considered to consist of two populations, one in the western North Pacific (WNP) and the other in the eastern North Pacific (ENP). The ENP population ranges from wintering areas off Baja California, Mexico, to summer feeding areas in the Bering, Beaufort, and Chukchi Seas. The WNP population feeds off Sakhalin Island and southeast Kamchatka, Russia. Historical evidence indicates that the South China Sea may have been used as a wintering ground in the WNP. Genetic, telemetry and photo-identification comparisons between the ENP and the WNP show some degree of population mixing during the winter. Here we present a multinational effort to evaluate trans-Pacific movements of gray whales photo-identified in both the ENP and WNP. Images of 379 whales identified on the summer feeding grounds off Russia (316 from Sakhalin; 150 from Kamchatka), were compared to 10,685 individuals photo-identified in the wintering lagoons of Baja California, Mexico (1,590 from Laguna Ojo de Liebre; 7,151 from Laguna San Ignacio; and 1,994 from Bahia Magdalena). A total of 42 matches were found, including 13 Sakhalin-Kamchatka-Mexico, 25 Sakhalin-Mexico, and 4 Kamchatka-Mexico. These matches consist of 21 females, 13 males, and 8 whales of unknown sex. Thirteen whales were observed making round trips (summer-winter-summer), 11 with winter in Mexico and the following summer in Russia, and 6 with summer in Russia and the following winter in Mexico. The others were matched in non-sequential years. These 42 matches, in combination with 12 previous matches, result in 54 gray whales being linked between Russia and Mexico. Movements between the WNP and ENP for at least 25% of the gray whales identified off Sakhalin Island and Kamchatka highlight the conservation and management importance of further examining gray whale population structure in the North Pacific.

Combining an unmanned aerial vehicle and computer vision to monitor and automate abundance counts of northern fur seals (Callorhinus ursinus)

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Visual counts of northern fur seals (NFS) have traditionally been collected by observers during the breeding season. However, NFS form dense aggregations on rugged coasts making visual surveys laborious and difficult to verify. We tested the utility of using an un-manned aerial vehicle (UAV), (Phantom 4 PRO) to collect aerial photos of NFS on a rookery to use for abundance counts. We flew the UAV at ~25 m altitude on transects overlapping by 50-75%. A single flight of an entire rookery produced about 1,000 photographs. Stitching and manually counting images proved laborious and time consuming but verified that visual head counts on images were accurate and replicable. To improve image processing, we used Photoscan software to stitch images into a high-resolution geo-referenced

orthophotoplan (OPP), eliminating the need to identify a border between distinct images when counting is performed on separate images. However manual counts of one survey on a single OPP still required up to 50 hours of observer time (e.g. one complete survey was approximately 26,000 fur seals). To reduce analysis time and optimize the aerial count method we evaluated the ability of a deep learning neural network known as U-Net to automate counts. This convolutional neural network was developed for biomedical image segmentation. We trained the U-Net to recognize and count individual seals on images by masking an area to be detected. In a preliminary test we created about 1,500 image-mask pairs and had the U-Net count an entire OPP map. Compared model count results was with at least 97.5% accuracy. This novel survey method substantially reduced survey cost and analysis time while producing highly accurate, reproducible, and verifiable results. These methods could easily be applied to the survey methods for other species found in high-density aggregations, for example at rookeries, haulouts or even migrating herds.

Plugging into marine mammal science: The power of the earplug.

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To understand the cumulative effects of multiple stressors on large baleen whales, it is imperative to quantify and understand both the types of stress (*e.g.*, intrinsic, extrinsic and ecological drivers) and their relative contributions. Therefore, the long-term goals of this project are to reconstruct lifetime (i.e. birth to death, ~6-month resolution) stress and stressors profiles in baleen whales using their earplugs. Reconstructed chemical and elemental profiles were derived by combining markers of stress (i.e. cortisol) and stressors profiles with age and date estimates derived from the earplug. Specifically, markers of reproduction, aging (DNA), foraging (i.e. bulk carbon and nitrogen stable isotopes), community structural shifts (i.e. compound-specific amino acid stable isotopes), and pollution were assessed. Lifetime hormone profiles, which resembles repeat sampling, were baseline corrected and provided an opportunity to combine profiles from different individuals, species, and generations. Stress and stressor profiles were reconstructed from blue, humpback, fin, gray, and Minke whales. Here, we present 150 years of stress data and examine historical relationships between cumulative stress and industrial whaling as well as current trends in baleen whales. Additionally, we highlight the utility of this matrix to assess pregnancy rates, climate change, contamination, community structure, and the long-term health impacts of stress. The results of this study will contribute to improving mitigation strategies through improved assessments of the potential impacts of anthropogenic activity.

Cultural geography of Eastern Caribbean sperm whales.

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Cetaceans have complex oceanic distributions that relate to their social structures. In the sperm whale (Physeter macrocephalus), a nomadic deep-diving species, females live in stable matrilineal social units which are themselves members of larger cultural clan defined by vocal dialects. Most of what we know of Caribbean sperm whale social dynamics comes from a long-term study off Dominica where over 20 social units have been monitored since 2005 and two vocal clans have been identified. It was expected that social units encountered in Dominica ranged throughout the Eastern Caribbean with, perhaps, differences in distribution between the two vocal clans, since studies in the South Pacific found sperm whales to have home ranges spanning around 2200km. To test these hypotheses, from February to April 2019, we surveyed the Lesser Antilles (between Grenada and St Kitts, spanning 550km) from a sailing vessel. When encountered, sperm whale groups were tracked from hours to days, while acoustic and photo identification data were collected. We had 38 encounters with female groups: 15 solely acoustic and 23 from which we obtained photo-identification data. All female encounters were leeward of the islands and only males were heard windward. Groups from both the EC1 clan (10 groups) and EC2 clan (7 groups) were identified throughout most of the survey routes. However, none of the previously identified EC1 social units were found outside of Dominica and Guadeloupe. Instead, 14 new sperm whale groups (4 probably EC1, 6 probably EC2, 4 unknown) were encountered around the other islands. In contrast,

one EC2 unit from Dominica was re-identified 170km away, off St. Lucia. These results suggest that sperm whale societies might be organized at a smaller scale than expected in the Eastern Caribbean and that the clans have distinctive ranging patterns.

First abundance estimate of the white whale (Delphinapterus leucas) stock in Svalbard, Norway.

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The Svalbard Archipelago in the Norwegian High Arctic is experiencing rapid declines in the seasonal duration and extent of sea-ice cover, and local tidewater glaciers are melting and retracting onto land. These changes represent a serious threat to all of the resident ice-associated species, including white whales (*Delphinapterus leucas*). White whale feeding in the past in this region was concentrated in front of tidewater glaciers and at edges and under annually formed land-fast ice. Despite extensive hunting in the past, no assessments of abundance have been conducted for white whales in this region, so neither the stock size, nor the stock trend, are known. The first ever aerial survey of the Svalbard white whale stock was conducted during the late summer in 2018. This survey covered: (i) coastline of all major islands in Svalbard (ii) major fjords and (iii) transects into the open ocean. A total of 265 individuals (in 22 groups) were detected along 4965 km of coastline transects. No white whales were observed along the 1481 km of fjord transects or along the 535 km of open ocean transects. After correcting for surface availability, using tracking data from the same stock in previous summer seasons, the Svalbard white whale stock was estimated to number 549 (95% CI 436− 723) individuals. This estimate is surprisingly low considering that this species is one of the most commonly observed Arctic cetacean in the area, but it does confirm suspicions based on challenges encountered in finding animals when operating tagging programmes. This first stock size estimate is important in the context of the rapid environmental change that is taking place in the region, providing an important baseline for comparison with future abundance estimates. It also represents an essential step in the local conservation and management of this species.

Marine mammal science and ethical dilemmas: The case of dolphin drive hunts.

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The dolphin drive hunts that occur annually in Taiji, Japan have received global condemnation on both welfare and sustainability grounds. The considerable ethical and political controversy surrounding these and other small cetacean hunts serves as just one example of a contemporary issue challenging experts in the field of marine mammal science. The ethical dilemmas facing the organizations active in marine mammal research and conservation, including the Society for Marine Mammalogy (SMM) and the European Cetacean Society (ECS), may become more pronounced as public and member interest in the protection of marine mammals grows through heightened awareness and exposure through social media. We present a historical timeline of the SMM's response to the dolphin drive hunt issue to illustrate the intersection of science and policy, while exploring the human dimensions that often drive conservation and welfare policy. We evaluate the challenges associated with integrating prevailing scientific knowledge with ethical, social and cultural dimensions of controversial marine mammal issues and examine the roles, boundaries and potential for international marine mammal societies in responding as a collective to policy issues and debates that are often compelled by scientific and public interest. We examine existing ethical guidelines within the SMM and ECS to explore the intersection of science and policy to assist in navigating increasingly complex threats to marine mammals. As professional marine mammal societies, should we develop policy positions on high profile marine mammal issues? What are the barriers to translational science and related advocacy within the marine mammal scientific community? A rapidly changing natural environment will only exacerbate the ever-changing social, political and cultural landscapes researchers face in disseminating and applying scientific data within management and policy arenas.

Effect of mussel farms on endemic endangered Hector's dolphins, Cephalorhynchus hectori hectori, at Banks Peninsula, New Zealand: An ecosystem perspective.

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With a growing human population, demand for food has steadily increased, as has pressure on marine resources. Over the last two decades, aquaculture production has increased dramatically, including in New Zealand, where the culture of green-lipped mussels (*Perna canaliculus*) has experienced rapid expansion. Nine mussel farms have been established at Banks Peninsula, home to a resident population of Hector's dolphins. In 1988 a marine mammal sanctuary created new restrictions on fishing, but did not affect aquaculture. Here we aim to assess the effects of mussel farms on Hector's dolphins from an ecosystem perspective. Therefore, their effect on the environment and the dolphins' habitat use was analysed in three bays with mussel farms (treatments) and three without (controls). The effect on water was measured via analysis of dissolved nutrients, and on sediment via analysis of organic matter. Habitat use by the dolphins was quantified through passive acoustic monitoring. Results showed significant differences (ANOVA, $p < 0.005$) in the dissolved nutrient content in the water and organic matter (%OM) in the sediment between bays and seasons. Sediment results indicated higher %OM in bays with mussel farms through all sampling seasons. Additionally, the %OM values were positively correlated with the farm's size ($r^2 = 0.42$, $p < 0.005$) and inversely correlated with distance from the farm. Acoustic data showed dolphin detections in all bays on >75% of days sampled. There were significant differences in detections between bays, but no consistent effect of mussel farms. In bays with farms, there were lower rates of detections adjacent to farms, compared with monitoring sites on the opposite side of the bay, suggesting small-scale displacement. This study suggests that mussel farms have significant impacts on the environment of Hector's dolphins. Their effects should therefore be carefully considered in future management of the habitat of this endangered species.

Where and when are you going? Unravelling distribution patterns of baleen whales through a bibliographic review.

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Macaronesia, an oceanic area located in the Northeast Atlantic, exhibits a high topographic and oceanographic complexity that enables a rich biodiversity. Among cetaceans, seven species of baleen whales have been recorded in the area. These are migratory animals that travel long distances between feeding grounds at high latitudes in summer and tropical areas for mating and breeding in winter. Being such mobile animals, the conservation and management of baleen whales' habitat is highly challenging. Hence, knowing and understanding the patterns of their distribution is fundamental. Despite the many records of baleen whales in Macaronesia, heterogeneity in research effort has resulted in scattered occurrence data that leads to an incomplete picture of their distribution in the area.

With that in mind, the aim of this study was to increase knowledge of distribution patterns of baleen whales and identify research effort gaps in Macaronesia.

From a total of 14 peer-reviewed publications, four public reports, two poster presentations, and four databases, we gathered 1798 records in Macaronesia since 1990 for four species of baleen whales: minke whale (*Balaenoptera acutorostrata*), fin whale (*Balaenoptera physalus*), blue whale (*Balaenoptera musculus*)and humpback whale (*Megaptera novaeangliae*). Spatio-temporal descriptive analyses and modelling were carried out in order to understand occurrence patterns.

The results show a big lack of research effort and occurrence data in offshore areas and in some coastal waters, namely off the West African coast. Moreover, blue, fin, and humpback whales are sighted mainly in spring in the north of Macaronesia, while minke whale distribution is clearly different, with a stronger presence in summer. This study highlights areas in urgent need of research effort in order to inform decision-makers and support effective measures for the protection and conservation of baleen whales in Macaronesia, an area crossed by the migratory corridors of these whales.

Skeletons in the closet: Investigating body size change in California sea lions over 60 years.

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Body size is a fundamental trait influencing the ecology and physiology of marine mammals. Several studies have suggested a size reduction in some pinnipeds species over the last few decades is a consequence of density-dependent intraspecific competition and indirect competition with commercial fisheries and/or of climatic variability. California sea lions (*Zalophus californianus*; CSL) present a unique opportunity to investigate the relationship between body size and population density. Population density has steadily increased since the 1970s after centuries of commercial sealing and now may be approaching carrying capacity. We hypothesize that CSL have reduced in size over the last decades with population recovery. To assess this hypothesis, we measured the standard (SL) and condylobasal (CBL) lengths of 296 adult male CSL skulls that stranded along the coast of northern California over the last 60 years. We grouped specimens by decade (<1970, 1971-1979, 1980-1989, 1990-1999, or >2000) and performed one-way ANOVA and Tukey's multiple comparison tests. Mean SL differed significantly among decades ($p < 0.001$), with significant differences between those smaller specimens from the 1960s and 1970s and the larger specimens from later decades ($p < 0.001$). The CBL was more stable over time; however, we found significant variation in the mean among decades ($p < 0.001$). Again, specimens from the 1970s and 1980s had smaller mean CBL than specimens from some later decades ($p < 0.05$). Overall, these results contrast with studies performed on other pinniped species, suggesting that local factors other than population density such as changes in primary production, prey composition, or interspecific competition are affecting body size in these animals. Further work is being conducted to explore these other mechanisms and the ecological consequences of these shifts in body size.

Cetacean Morbillivirus infection in a Guiana dolphin (Sotalia guianensis) off the coast of Sao Paulo, Brazil: A case report.

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By-catch is a major threat to cetaceans worldwide. Factors predisposing to by-catch may not be apparent in many instances; however, systemic infectious diseases could play a role. *Cetacean Morbillivirus* (CeMV) is a highly contagious pathogen that may cause significant morbidity and mortality in various odontocete and mysticete species. Hereby we provide pathologic evidence of CeMV infection in a Guiana dolphin (*Sotalia guianensis*) representing the first case confirmed in south-central coast of Sao Paulo state, Brazil. A 28 kg, female, juvenile (2-yo according to dental analysis) Guiana dolphin stranded dead in Praia Grande, São Paulo (-24.075061; -46.5761138), in September 10th, 2018. The animal was collected during the Santos Basin Beach Monitoring Project (*Projeto de Monitoramento de Praias da Bacia de Santos* - PMP-BS), one of the monitoring programs required by Brazil's Federal Environmental Agency, IBAMA, for licensing process of the oil production and transport by Petrobras at the Santos Basin pre-salt province. The carcass was fresh at necropsy. Grossly, linear erosions and lacerations compatible with by-catch were observed in the rostrum, peduncle and pectoral and caudal fins. Additional findings included: pulmonary edema and hemorrhage; verminous pneumonia (*Halocercus brasiliensis*); middle ear trematodiasis (*Nasitrema attenuate*). Microscopically, the main lesions were: marked pulmonary edema; bronchointerstitial pneumonia with necrotizing bronchiolitis and intracytoplasmic and intranuclear inclusion bodies; eosinophilic and lymphoplasmatic and proliferative pleuritis with intralesional *H. brasiliensis*; and cerebral lymphocytic meningitis. PCR analysis for *CeMV* was positive in lung and lymph nodes. To our knowledge, this is the first report of CeMV in a Guiana dolphin from the south-central coast of São Paulo state, Brazil. These results have implications for CeMV dynamics and geographic range. In the present case, the cause of death was ascribed to by-catch. Nonetheless, the severity and extent of concurrent CeMV infection and endoparasitism might have played a role predisposing to by-catch.

Behavioral contexts change the social connectedness of individual dolphins specialized in foraging with fishermen

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Social interactions among animals are diverse and dynamic, forming heterogeneous social environments within which some individuals are more connected than others. This heterogeneity can stem from multiple factors—from the ecological environment to individual traits. While individual behavioural specialisations has been shown to structure animal population, how they modulate sociality at the individual level is much less clear. Here we investigated whether a specialized foraging tactic can influence individual social connectedness. In southern Brazil, a population of bottlenose dolphin (*Tursiops truncatus*) forages with net-casting fishermen. Not all dolphins use this tactic with the same frequency, which shapes the population into distinct social modules—those that often and those that rarely forage with fishermen. We tested if the frequency of foraging with fishermen influences the number of social associations dolphins maintain during two behavioural contexts—foraging and not foraging. We found that dolphin that frequently forage with fishermen tend to have a higher number of associations when foraging (β=0.005, SE=0.001, Z=4.474, df=30, P<0.001), being more socially connected and central in the social network. However, this pattern reverses outside of the foraging context: dolphins that often interact with fishermen have fewer connections (β=-0.005, SE=0.001, Z=-3.812, df=30, P<0.001). Despite changes in network centrality, social modules were noticeable in both behavioral contexts. These results suggest that social preferences are context-dependent and illustrates how specialized behavior can influence social patterns at the individual and the population level.

Key-words: bottlenose dolphins; *Tursiops truncatus*; social networks

Does dental variation reflect the level of genotypic variation in ringed seals?

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Pinnipeds tend to exhibit higher dental variability than mammals in general, usually attributed to the lack of tight occlusion. This suggests that selection in tooth shape is relaxed in seals. Moreover, their permanent teeth form and erupt already during prenatal development, which implies that tooth shape is predominantly determined during development and little affected by environment. Therefore, we hypothesize that phenotypic variation in seal teeth should reflect the level of genotypic variation in a given seal population. We examined ringed seals (*Pusa hispida*) by comparing four populations of different sizes: two marine populations, Arctic (*P. h. hispida*) and Baltic (*P. h. botnica*), and two isolated lake populations, Ladoga (*P. h. ladogensis*) and Saimaa (*P. h. saimensis*). The population sizes of the Arctic, Baltic, Ladoga, and Saimaa seals are >1,500,000, >11,000, >3,000 and ~400 seals, respectively. We assessed the level of phenotypic variation in lower postcanine teeth (P2-P5) by examining cusp number and size. We utilized museum collections and inspected >250 individuals from each population. In order to assess the level of genotypic variation, we sequenced genomes of ten seals from each population. As expected, the marine populations showed the highest phenotypic and genotypic diversity, whereas the smallest population, Saimaa, stood out with clearly the lowest phenotypic and genotypic variation. Our study suggests that even though mammalian dentitions are generally highly adaptive structures, in seals dental variation could be used as a proxy for the level of genotypic variation.

Estimating entanglement and vessel collision scarring rates in southeast Alaskan Humpback whales (Megaptera novaeangliae) using unoccupied aerial systems

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As capital breeders, humpback whales (*Megaptera novaeangliae*; HBW) rely heavily on accumulated energy reserves to meet the costs of growth,

migration and reproduction. Fishing gear entanglements and vessel collisions impose significant demands on the energy budgets of large whales - the equivalent of an unnatural and taxing life-history stage. While previous studies have utilized boat-based photography to estimate scarring rates of rorqual species, these rates are likely underestimates because sub-surface scarring may not be detectable from research vessels. This study used Unoccupied Aerial Systems (UAS) to estimate the proportion of non-lethal entanglements and vessel strikes among HBW in southeast Alaska (SEAK). The dorsal surface of each whale was divided into five regions (pre-blowhole, post-blowhole, dorsal fin, peduncle and caudal flukes), with scarring codes assigned to each region based on the presence/absence of scarring deemed consistent with previous entanglement or vessel collision. From this, individual whales were assigned a likeliness code subsequently used to calculate minimal, conditional and maximal scarring percentages. Between July and August 2018, 90 UAS flights were conducted during 13 boat-based surveys. From a sample of 68 individually identified HBW, we report minimal, conditional and maximal scarring proportions of 35.1%, 43.1 % and 53.7%, respectively. Our results coincide with previous boat-based scarring analyses for HBW in SEAK (52–78%) and the Gulf of Maine (48–65%), but exceed rates estimated for HBW in Iceland (24.8%). We demonstrate how UAS provide a novel perspective from which to quantify scarring rates in a cost-effective and efficient manner. Since HBW in SEAK form part of the Hawaii distinct population segment, future analyses will expand to include HBW in Hawaii. An enhanced understanding of anthropogenic sources of HBW mortality is imperative, with vessel-related HBW mortality rates in US West Coast waters estimated to be twice the recommended potential biological removal limit.

Lessons from a decade of monitoring coastal dolphins in port areas in Brazil: Guidelines to improve and align monitoring actions.

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Port areas are globally expanding and impacting the marine environment, particularly coastal dolphins, which are sentinels of the ecosystem health, quality and functioning. Therefore, their monitoring should be included in environmental management, planning and Environmental Impact Assessments (EIA). However, this integration poses a variety of challenges. Since 2007, our team has been monitoring Sotalia guianensis, a near threatened coastal dolphin, at one of the largest agricultural ports of South America, Paranaguá, which is located adjacent to a World Heritage Site. A variety of methodologies have been applied, such as occurrence, abundance and distribution estimates by photo-identification and line transect surveys, collection of stranding data, health assessments and acoustic monitoring. During this decade, many ways to improve monitoring of coastal dolphins in port areas have emerged. The most significant improvements to standard monitoring practices can be summarized in six general categories: **(1) Sampling design:** selecting adequate sampling days. **(2) Sampling methods:** categorizing anthropogenic activities (e.g. dredging, vessel traffic, pile driving); photo-identification recording group size and composition, habitat use, behaviour and skin diseases; recording bioacoustics to evaluate sound interferences; collecting stranded carcasses for histopathology and contamination levels. **(3) Data analysis:** improving health assessment; associating distribution with habitat quality and health scores; defining standard acoustic behaviour and evaluating potential masking impacts on dolphins' communication. **(4) Interpretation of the results:** assessing synergetic and cumulative impacts generated by different port activities. **(5) Communication of the results:** reducing the knowledge gap between the academic world and other port stakeholders. **(6) Implementation of results in environmental management and planning:** minimizing disparity between research and policy; improving feedback loops in management and planning cycles. These findings allowed the establishment of a set of guidelines to monitor dolphins in port areas, enhance EIAs with cetacean monitoring, and provide baseline support to align mitigation and conservation actions in port areas.

Oceanographic barriers, divergence, and admixture: Phylogeography and taxonomy of two putative subspecies of short-finned pilot whale.

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In cetaceans, taxonomic uncertainty due to the difficulty of obtaining morphological data can hamper our understanding of the drivers of evolution in these species. We use genomic data to examine these forces in the short-finned pilot whale. While being recognized as a single global species, it includes at least two distinct morphological forms originally described in Japan: the 'Naisa' and 'Shiho' forms. We first examine phylogeographic patterns of divergence using mitogenomes (N=181 samples) and nuclear SNP loci (112 SNPs, 105 samples), and find evidence for three evolutionarily divergent types within the species. Next, we test taxonomic structure among those types using mtDNA control region sequences (345 bp) from 735 globally distributed samples, which indicate subspecies differentiation between two of the types, separated by the East Pacific Barrier: the Shiho subspecies (eastern Pacific Ocean and northern Japan) and the Naisa subspecies (Atlantic, Indian, and western/central Pacific Oceans). The third type, found only in the Atlantic Ocean, is a divergent population within the Naisa subspecies, separated from the western/central Pacific and Indian Oceans by the Benguela Barrier off South Africa. Finally, we sequence a representative nuclear genome from each of the three different types and a long-finned pilot whale to further examine their evolutionary relationships. Results from analyses of these full genomes suggest differences in ancestry shared with the long-finned pilot whales between the types of short-finned pilot whales, which could indicate incomplete lineage sorting or inter-specific introgression, with no significant mixing between the three types of short-finned pilot whale.

Linking climate and ocean productivity to the prevalence of southern right whales (Eubalaena australis) in South African waters

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South African coastline surveys conducted since 1969 reveal fluctuations and a recent reversal in a long-running increasing trend in abundance of southern right whales (*Eubalaena australis*, hereafter SRWs), whose populations have been recovering from historic whaling. Furthermore, the surveys reveal that the typical three-year calving cycle of female SRWs has shifted to four- or five years, implying either additional resting years between successive calving events or calving failure. This study used wavelet analysis, an effective method of time series analyses on non-stationary data, to reveal significant synchrony in the cycles of SRW cow-calf pair counts and various climate indices (Oceanic Niño Index, September Antarctic sea ice extent and the Antarctic Oscillation) as well as ocean colour (January chlorophyll a concentrations in three putative SRW feeding grounds). In addition, autoregressive integrated moving average (ARIMA) models were used to investigate the potential role played by ocean colour and the various climate indices in the inter-annual fluctuations of cow-calf pair counts, as well as the recent reversal in their increasing trend of local abundance. The impacts of climate are thought to be mediated through the influence of physical oceanography on SRW prey (krill and copepod) availability, while chlorophyll a concentrations have been found to correlate with densities of SRW prey. These aspects ultimately impact feeding success and body condition of SRW, and consequently their reproductive

condition and migratory behaviour. ARIMA models analysing the inter-annual fluctuations in SRW cow-calf pair counts reveal significant model performance improvement through the inclusion of the Antarctic Oscillation and chlorophyll a concentrations from two of the three putative SRW feeding grounds. Results from this study indicate that annual fluctuations in SRW calf abundance in coastal South Africa appear closely influenced by feeding ground productivity and global climate indices, mirroring similar findings for South American and Australian SRW populations.

Generational cycling of PCBs in harbour porpoises of the southern North Sea

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Polychlorinated Biphenyls (PCBs) may still negatively impact the harbour porpoise (*Phocoena phocoena*) population in the southern North Sea, even though bans on the use of these chemicals already started in the 1970s. This study focused on presenting an overview of PCB concentrations in age classes and sexes of harbour porpoises that beached along the Dutch coast (2006-2017). This provides information on different uptake routes of these contaminants in harbour porpoises during their life cycle and the influence of maternal off-loading to consecutive offspring. PCB concentrations were analysed in several sample types: blubber (all age classes: foetus, neonate, juvenile, adult), milk and placenta (adult females). Lowest PCB concentrations were found in blubber samples of foetuses. In males, PCB concentrations increased with increasing length, whereas in females concentrations decreased once animals reached the adult age class due to maternal offloading. Transfer of PCBs via lactation appeared to be a more important route than placental transfer, and was followed by uptake from food. Neonates, juveniles and adult (males) contained PCB concentrations up and above levels that may exert physiological or reproductive effects. This study further confirms that PCBs remain in the harbour porpoise population for a long time. Further insight into the role of PCBs and other contaminants effecting the health status of harbour porpoises is therefore needed.

Bottlenose dolphins in the Sound of Barra (western Scotland): A community with the potential to flourish, or one doomed to disappear?

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Effective management of coastal developments requires accurate, up-to-date, and site-specific information on the spatio-temporal presence of local populations, and the underlying anthropogenic and natural drivers.

Using a combination of photo-identification (1995-2018) and acoustic C-POD data (2010-2013), this study collected information on population size, site fidelity, and life-history parameters (gender, calving rate, survival, inter-birth interval), and investigated year-round presence and relationships with environmental conditions, of a small bottlenose dolphin (*Tursiops truncatus*) community occupying the Sound of Barra (SoB) and surrounding waters off western Scotland.

Results showed that, based on >16,000 photographs, the community size has remained fairly stable at least since 2006 (limited efforts for earlier years prevented full assessment), consisting of ≤15 individuals annually, with a total of 19 dolphins identified. Summer site-fidelity of >20 years was observed for several individuals. Sex was determined for thirteen individuals, and a one-tailed binomial test on gender ratio confirmed that the community was female-dominated (three males and ten females). Results pertaining to the other biological parameters, although limited in available data, were comparable to those reported for other coastal populations.

Over 900 days of C-POD monitoring revealed a year-round presence of dolphins, with increased probability of detecting dolphins around sunset and sunrise. Despite close proximity between the two acoustic monitoring locations (<7 km), contrasting relationships with the tidal cycle were found, suggesting site-specific usage of these areas.

Although this community may represent an embryonic group with potential to grow, it is also plausible it represents a remnant of a previously larger group. As such, given the stochastic effects on small populations and potential Allee effects, the low numbers of reproducing females, in

combination with the community's geographic, and apparent social and genetic isolation from other dolphins, the future viability and existence of this community is of conservation concern.

Grey seal (Halichoerus grypus) predation on marine mammals in German waters – new tools and methods to determine predator identity.

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Within the last years, scientific reports showed that grey seals throughout their European range utilise harbour porpoises, harbour seals as well as conspecifics besides their predominantly piscivorous diet. The present study gives a comprehensive overview of the current state of knowledge on the predation of marine mammals by grey seals in German waters. Outcomes of a retrospective analysis of necropsy results of suspicious harbour and grey seal (n = 417) and harbour porpoise (n = 1070) carcasses stranded on the coasts of Schleswig-Holstein throughout 27 years will be summarised focussing on pathological investigations of the retrieved carcasses along with behavioural observations. Occurring wound patterns are described and summarised in the form of assessment criteria and verified using two case reports. Suggested diagnostic parameters include lacerations with a linear, cut-like wound margin, large parts of detached epidermis and underlying tissue, as well as the loss of blubber tissue. Additionally, assessment criteria which aim to identify an interaction with predatory or scavenging foxes are suggested. Findings will be discussed in the context of observed predation behaviour, which can be regarded as largely consistent over time and between individuals. It is characterised by a prolonged phase of feeding during which mainly blubber tissue is removed by repeated teeth scraping over skin flaps. Whether this behaviour is part of a general specialised feeding strategy or rather related to an individuals' personality remains unclear. With regard to the presented findings, it must be assumed that this behaviour is at least regionally widespread. However, our understanding is not yet sufficient to conduct a comprehensive assessment of the ecological relevance and should therefore be a major focus of future research. Likewise, the use of standardised assessment criteria like the ones presented here, should be the common goal for future cross-national comparisons of recorded data.

Using passive acoustic data to explore spatio-temporal patterns in marine mammal community composition.

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To date, the majority of studies investigating marine mammal distribution and behavior take a single-species perspective, which is often driven by the logistic difficulties of collecting appropriate data at sea. Passive acoustic monitoring tools, provided these exhibit sufficient bandwidth, have the potential to provide insights into community structure as devices operate autonomously simultaneously collecting data on baleen, pinniped and toothed whale acoustic presence. Data can provide information on local species diversity, residency times and patterns in species co-occurrence.

Using multi-year passive acoustic data from 6 sites in the Weddell Sea, Atlantic sector of the Southern Ocean, we here explore how local marine mammal community compositions develop over time.

We show that the effective number of species exhibited little variation over time, reflecting that species remain in Antarctic waters throughout austral winter. Community composition showed almost complete seasonal overturn, recognizing that species replace each other throughout the year. For all 6 sites, community dissimilarity increased with increasing temporal distance reflecting temporal trends in community composition beyond seasonality. Several species exhibited significant positive or negative co-occurrence patters over time, suggesting predator-prey relationships, competition for prey species as well as acoustic

interference between co-occurring species. These seasonal associations were consistent across and between all oceanic sites, but partly inversed at the Western Antarctic Peninsula recording site. This study shows that the application of biodiversity metrics to PAM data can foster insights to the timing of behaviors and community composition, which can boost the interpretation of responses in the light of ongoing environmental changes.

Numerical models to investigate North Atlantic right whale encounter rates with snow-crab gear in the Gulf of St. Lawrence.

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Fishing-gear entanglements are a substantial source of injury and mortality among endangered North Atlantic right whales (NARW(s); *Eubalaena glacialis*). NARWs occupying the southern Gulf of St.Lawrence (sGSL) have been observed swimming and feeding near high densities of snow-crab fishing gear. The number of NARWs observed in the sGSL has increased since 2015; coincident with an increase in reported NARW entanglements in snow-crab and unidentified gear. The goal of this study was to use numerical models to estimate the frequency of NARW encounters with the snow-crab gear, as each encounter represents a potential entanglement. We combined the time and space gear distribution data (2015-2018) with empirically informed NARW movement models to estimate temporal and spatial variability in simulated whale encounter rates with the snow-crab gear. Due to the uncertainty in the timing and immigration rates of NARWs into the sGSL we present four models of immigration rate: constant, linear, and emigration rates from Cape Cod Bay, and the discovery curve of individuals in the sGSL; each used to populate movement models of individual whales. In 2017, there was an unusually high landings quota in the snow-crab fishery with ~45,500 traps reported and repeatedly deployed in the sGSL for a cumulative exposure of ~3.2 million trap-days. The trap-days were approximately half that level in 2015 and 2016 with ~36,000 traps and ~1.8 million trap-days reported in each year. Preliminary analyses indicate ~two-fold and ~four-fold increases in the average number of encounters between whales and gear when comparing 2015 and 2016, respectively, to 2017. Fisheries management measures in 2018 included static and dynamic area closures, and through the simulations we also examined the "fence effect" of these closures on encounter rates. We propose these models can inform fisheries management policy options and decision-making, and to assess the effectiveness of the conservation measures implemented.

Keep an eye on me: Using underwater photos and video from citizen science to evaluate prevalence of injury in pygmy killer whales (Feresa attenuata) in Hawai'i.

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Assessing injuries and body condition of cetaceans has often been limited by what can be seen from the surface; while photos contributed from the public can help fill gaps in sighting histories, the recent increase in the use of inexpensive high-resolution underwater cameras allow better assessment of an animal's overall health. Underwater photos and video taken primarily from citizen science contributions off O'ahu and Hawai'i from 2006-2018 were used to examine the origin (anthropogenic or natural), type (using 10 predefined categories), and prevalence of external injuries in 55 individual pygmy killer whales known to be resident to the islands. Out of 39 encounters with 2,343 good quality underwater photos, 124 injuries were recorded and all individuals had at least one injury (mean=3.2, SD=1.2). Only 15.8% of injuries recorded underwater were completely visible in encounters with surface photos (n=33), revealing how many injuries may otherwise go undetected. Cookie-cutter shark (*Isistius* sp) bite scars (91% of individuals) and conspecific rake marks (85% of individuals) were most frequently observed. Both deep linear scars (55% of individuals) and mouthline scars (43%) were biased by sex. Adult males had much higher rates of both (81% with linear scars, 74% with mouthline scars) compared to adult females (19% and 26%). In addition to mouthline injuries that may reflect prior fishery

interactions, two individuals with bullet-shaped wounds not visible from the surface, and one with a propeller strike wound, provide evidence of interactions with humans. Only 8% of individuals in our photo-ID catalog were evaluated and thus underrepresent the number with likely anthropogenic injuries. Underwater citizen science contributions, particularly when combined with surface photos often necessary for identification, can increase documentation of injuries otherwise not visible. Obtaining additional underwater and surface imagery would allow for a better assessment of injuries from both natural and anthropogenic sources.

Acoustic monitoring targeting MSFD's good environmental status and cetacean conservation

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The Marine Strategy Framework Directive's Good Environmental Status (GES) is being targeted by European Member States around the Mediterranean Sea by 2020. This should also improve conditions for cetacean survival in this region. Among the various anthropogenic pressures to monitor and regulate there is marine noise which falls under descriptor 11 of the MSFD. Investigating the often underestimated levels and impacts of marine sound pollution at a regional level is essential to effectively monitor and reduce this increasing environmental problem. Pilot projects in Western, Central and Eastern Mediterranean areas, undertaken as part of the QUIETMED project allowed critical investigation of the methods and strategies to achieve the requirements for Descriptor 11 in two '1/3-octave bands' (i.e. 63Hz and 125Hz) while also providing means for acoustic monitoring of cetaceans in these study sites. In the central Mediterranean, off the Maltese Islands, the deployment of two Passive Acoustic Monitoring Systems, using RTSys SDA14 recorders for monthly recordings, was first undertaken in 2018. This provided a vital investigation on the status of marine sounds in the two areas situated at different distances from the main vessel traffic paths, following MSFD requirements. The acoustic recordings in these two locations also contributed useful data on cetacean presence in the same spatiotemporal situations being analysed. Such monitoring strategies, that allow simultaneous monitoring of ambient sounds originating from anthropogenic activities and from natural sources including cetacean species, strengthen the effectiveness, rigour and implications of the extent to which GES for marine sound levels may be achieved. Elusive and vulnerable cetaceans are considered conservation flagship and umbrella species but also important indicator species, so local to regional acoustic studies reveal how their distribution also relates to sound variability in a heterogeneous Mediterranean marine environment.

Current flows cause variation in high frequency noise at a fine scale: Implications for passive acoustic studies of high frequency cetaceans.

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Passive acoustic monitoring (PAM) studies are widely used to investigate cetacean encounter rates, distribution, and associations with local environmental variables. Many coastal and tidal regions experience fast currents, which in turn creates noise from sediment flow and in some cases additional noise created by turbulence passing PAM devices. As noise increases, the effective detection area is likely to be reduced. Therefore, a study that does not consider variable detection range may result in inaccurate findings. This study investigated relative detection range of harbour porpoise (*Phocoena phocoena*), a species commonly studied using PAM, using sea-bed recorders and demonstrates the implications for analyses. Seven SoundTraps were deployed approximately 500m apart at a coastal site that experiences moderate tidal range and current speeds. SoundTraps continuously recorded full-bandwidth noise and porpoise signals. Deployments were repeated shortly after, using a high frequency click detector to allow longer data collection of porpoise vocalizations to investigate associations with environmental variables. Each site experienced noise variation in the harbour porpoise bandwidth as a result of tidal current flow. During certain periods, sediment noise presented similar characteristics to porpoise echolocation clicks. Variation in click received level mirrored

trends in noise variation, suggesting first possible evidence of the Lombard effect in harbour porpoise, where animals compensate for high noise by vocalising at higher amplitudes. Porpoise detections were present during loudest periods suggesting that masking may not be present. Considerable noise variation was recorded between recorders less than 1km apart, suggesting implications for studies that compare between sites. Porpoise associations with predictor variables were revealed between sites when noise was not incorporated into analysis. Results suggest that it is key to measure fine-scale noise conditions in conjunction with spatio-temporal acoustic studies of cetaceans of distribution and behaviour.

Mom, can you hear me? Impacts of underwater noise on mother-calf contact calls in endangered belugas (Delphinapterus leucas).

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Noise and anthropogenic disturbance from recreational and commercial vessel traffic were identified amongst the main threats to the recovery of the endangered St Lawrence Estuary (SLE) beluga population. The consequences of acoustic masking could be particularly adverse in the case of critical vocalizations that maintain contact between mothers and their dependent calves. Here, we modeled communication range of adult and newborn beluga broadband contact-calls under quiet and noisy conditions in Baie Sainte-Marguerite, an important summering area for this population. To do so, we used measurements of ambient noise obtained with a calibrated hydrophone in the presence and absence of boats (verified visually from an observation tower), a composite beluga audiogram based on thresholds pooled from all individuals tested with AEP and behavioural methods, and apparent source levels of adult and neonate contact-calls. Source levels were estimated from received levels of contact calls recorded from two wild populations (SLE and Eastern High Arctic) and from Oeanogràfic aquarium (two adults and a neonate) at known distances from a calibrated hydrophone, with propagation loss equations suited to each location, and from contact-calls recorded from five individuals carrying temporary Dtags (SLE). The modeled median distance at which the signal excess reached zero in all 1/12 octave bands analyzed (487 to 97162Hz center frequencies), considered the maximum communication range, was considerably reduced in noisy conditions, particularly for neonates, given that their calls had substantially lower source levels and peak frequencies than adult contact-calls. Thus, a neonate's call would suffer a 56% reduction in range to a median distance of 190m in noisy conditions. The estimates in our study are the first approximations of source levels and active space of beluga calls with a known function, and show that masking of these calls by noise may be particularly problematic for the underdeveloped contact-calls of neonates.

Effects of boat activity on bottlenose dolphin foraging behaviour

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In many parts of the world, impacts of recreational activities have focused on cetaceans' displacement. Nonetheless, changes in behavioural patterns of cetaceans that do not flee may also pose a threat. In Cardigan Bay, UK, two Special Areas of Conservation have been established to protect bottlenose dolphins (*Tursiops truncatus*). However, over the past decade, human pressures have increased markedly. Careful management is needed to conserve this population whilst safeguarding its socio-economic value. This study aimed to evaluate possible effects of boat disturbance on bottlenose dolphin presence and foraging activity in the southern SAC, where a long-standing code of conduct with good compliance is found. Acoustic detections recorded with acoustic data loggers (T-PODs) from 2005 to 2008 during the summer season were obtained from ten different sites within Cardigan Bay SAC to evaluate how boat disturbance affected bottlenose dolphin foraging activity. Generalised linear models (GLM) were used to test bottlenose dolphin presence and stages of foraging behaviour (recorded as buzz occurrence) and the effect of noise level at different moments of a boat encounter at different sites. Results show an increase in bottlenose dolphin presence and in foraging activity when boats are around. In addition, foraging activity seemed to stop when boats were leaving the area at

all sites but particularly at those where boat activity was lower. We conclude that dolphins maintain occupancy despite vessel presence but alter their behaviour during a boat encounter. Therefore, dolphins may increase feeding because they cannot socialise or rest in the presence of boats, or because the cetaceans have habituated to the boats and do not see the motorised vessels as a threat, linked to their code of conduct compliance. Results highlight the value of enforcing regulations, contributing to an area-based management scheme that promotes species conservation alongside a sustainable ecotourism-industry.

New subspecies of bottlenose dolphin (Tursiops truncatus gephyreus) classifies as Vulnerable under IUCN criteria

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A recent reassessment of the world-wide taxonomy of *Tursiops* confirmed the validity of the subspecies Lahille's bottlenose dolphin (*Tursiops truncatus gephyreus*; Lahille 1908). These dolphins are distributed in the coastal waters of the southwest Atlantic Ocean, between the state of Parana (southern Brazil) and the province of Chubut (Argentina). They occur in two genetically and geographically isolated "subpopulations" under the IUCN definition: one ranging along the coast of southern Brazil and Uruguay, composed by at least five management units and operating as a metapopulation, and a second ranging along the coast of Argentina.

The abundance of Lahille's bottlenose dolphins has been estimated for most parts of the subspecies' range. The sum of available estimates suggests a maximum total population size of 600 individuals. With an estimated 60% of mature individuals, the total number of mature individuals in the subspecies can be estimated at 360, well below the threshold to classify as Vulnerable under Criterion D. Due to their low numbers, high site fidelity and restricted coastal distribution, Lahille's bottlenose dolphins are particularly sensitive to local anthropogenic impacts.

The genetic variability of Lahille's bottlenose dolphins is low at both nuclear and mtDNA markers, and there is evidence that the subspecies is declining in at least part of its range due to bycatch in fisheries and other unknown factors. Of particular conservation concern is the Argentina subpopulation, due to its low and likely declining abundance (of at most 140 mature individuals), genetic isolation from the rest of the subspecies and its low genetic variability. However, robust data are still lacking to quantify the population declines, and the possible consequences for the subspecies' conservation status. It is therefore a priority to obtain improved estimates of population dynamics and life history parameters for each subpopulation, for which continuous dedicated research efforts are crucial.

Are Tursiops truncatus modulating the whistles parameters during mixed groups contexts?

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Cetaceans depend highly on acoustic signals to communicate, navigate and find food. Mixed groups contexts, characterized by temporary and opportunistic encounters between different species, may play an important role on the acoustic dynamics of the species involved. Considering the communicative function of whistles, we used these sounds to investigate the acoustic relationships between *Tursiops truncatus* when involved on mixed groups contexts versus when not involved. Acoustic recordings of interspecific associations of *T. truncatus* with *Globicephala melas* and with *Grampus griseus* were collected and compared with recordings of *T. truncatus* in a single species context. Both type of the recordings were performed with omnidirectional hydrophone array coupled to a digital recorder (sampling frequency of at least 96 kHz/24 bits) on the western South Atlantic Ocean. A total of 1267 whistles were analyzed and the following acoustical parameters were extracted: minimum, maximum, center, delta, beginning and ending frequencies, first and third quartile frequencies, first and third quartile of

duration, inter-quartiles range of duration and frequency, frequency at 95% and 5% and whistle duration. In order to verify if whistles of single species groups of *T. truncatus* were different from the interspecies associations, a Support Vector Machine (SVM) model - a machine learning method useful to detect patterns among groups of different classes - was implemented. SVM analysis showed a clear separation of whistles, with an error rate of 9,5% for both analyzes (between the contexts: single species versus the mixed group with *G. melas* and between the single species versus the mixed group with *G. griseus*). The results show that interspecific associations between dolphins may influence whistle structure and highlights that *T. truncatus* whistles can be modified during interspecific interactions. Multi-species associations of odontocetes remain poorly understood; thereby these findings can be useful to elucidate the possible driving factors behind these interactions.

Male humpback whale song behaviour: Singing while on the move.

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Male humpback whales, *Megaptera novaeangliae,* are known for producing complex song while on the breeding grounds. Their song is seemingly part of a vocally mediated mating sexual display to either attract females and/or deter other males. Thus, a large acoustic active space of song could be of importance to the fitness of males. Previous studies which investigated the behavior of singing males have been limited by observational platforms. A better understanding of how males move geographically and distribute song in a breeding area, could help understand the potential impact of anthropogenic disturbances and noise. We therefore sought to investigate the fine-scale movement behavior of singing male humpback whales with animal-borne sound and movement tags (DTAGs). These tags record GPS, sensor and acoustic data providing a direct link between behavior and singing. Our aims were to investigate i) the type of behavior exhibited during singing bouts and ii) whether males transit to a new location between singing bouts, potentially to increase their acoustic active space. We analyzed 46 hours of tag data from four humpback whales on a breeding ground in Exmouth Gulf, Western Australia. We show that males sing for long bouts (49±34 min), during the day and night, and at high received levels ranging from 149-178 dB re 1uPa. Males exhibited both highly active (e.g. fast swimming) and stationary behavior during singing, showing that singing is dynamic and not produced solely during slow swimming or stationary behavior as previously documented. The body position of males during singing was both horizontal and vertical in the water column. Three whales tagged with GPS covered 4.8±2 km/hr, with this movement between singing bouts showing an active increase of active space of song. By improving our understanding of male humpback behavior on breeding grounds we can better inform conservation efforts.

Humpback whale song variations in Reunion Island from 2016 to 2018

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Sexually mature males produce very complex and highly structured songs which are shared at the population level. Song pattern (phrases) are culturally transmitted and have been described to evolve progressively with time, both over the breeding season and among years. Acoustic monitoring was conducted over multiple years around Reunion Island, within the southwest Indian Ocean breeding range, to assess temporal variation in song structure and in humpback whale occurrence. Continuous recording was undertaken during the austral winter (June-October) for 3 consecutive years in 2016-2018. A total of 44 samples containing high-quality song sequences from the early, mid- and late season were selected, representing 2 640 minutes of recordings. The analysis of song structure resulted in the description of 12 phrases and their variants. Low level of temporal variation was observed over the breeding season, with songs recorded in June being very similar to the one recorded late in late September-early October. Higher variations were observed between years, with some phrases from 2018 that may have evolved from phrases from 2017. In 2017 and 2018, more variants were described for each phrase type compared to 2016, in consistency with humpback whale occurrence.Very low number of humpback whales were observed around the island in 2016, which

might have resulted in a lower diversity in song pattern.

The missing whales: Accounting for "struck and lost" rates in the assessment of historical whaling impacts in the Southwestern Atlantic Ocean.

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Open-boat historical whaling had a massive impact on a number of cetacean populations worldwide. Several attempts have been made to estimate the actual number of individuals taken by this activity. Most of them were based on the records of oil barrels or baleen plates discharged at port at the end of each whaling voyage. But what about whales that were struck, slightly or severely injured, and subsequently lost by whalers? These deaths may have contributed to the demographic impact of whaling over some cetacean populations. Here we consider the records extracted from 255 logbooks from the offshore historical whaling industry in the Southwestern Atlantic Ocean. Data from approximately 20,000 days on effort were extracted from the period ranging from the end of the XVIII century until the first decades of the XX century. According to these records, whalers first targeted the Southern right whale (*Eubalaena australis*), reporting approximately 2,500 sightings and 658 catches, and during the latter period, the sperm whale (*Physeter macrocephalus*), reporting 1,155 sightings and approximately 800 catches. When assessing these logbooks for the "struck and lost" rates, however, these numbers increase, with over 340 additional Southern right whales and 90 sperm whales lost after being wounded. The different rates for the two species may be related to behavioural differences of the two species or to an improvement in whaling techniques, proportionally reducing "struck and lost" rates in the latter period, when the operation mostly focused on sperm whales. For the Southern right whale, however, whose population was drastically reduced by whaling, we estimate that the proportion of whales killed was approximately 1.5 the number of whales actually caught and taken to port. Accounting for these "lost" individuals is fundamental when reconstructing demographic trends of cetacean populations targeted by whaling.

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Discovery of sound in the sea: Communicating underwater acoustics research to decision makers.

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Anthropogenic activities related to the production of underwater sound are subject to a wide range of environmental regulations. The decision making and regulatory communities must often rapidly synthesize new scientific research results to properly implement regulations and accurately assess potential impacts of proposed projects. To address these needs, the University of Rhode Island Graduate School of Oceanography teamed with Marine Acoustics, Inc. on the *Discovery of Sound in the Sea* (DOSITS) Project. The Project's foundation is an interactive website (dosits.org) that synthesizes peer-reviewed science related to underwater sound, including content on sound sources, potential impacts on marine life, and how animals and people use sound underwater. The site has over 400 content pages and is updated semi-annually with newly published information after a thorough review by a panel of scientific experts. To identify regulator and decision maker needs, four surveys were conducted (2015-19), leading to the development of high-need underwater acoustics content and associated resources. Current DOSITS Project activities include webinars, which consist of presentations by experts followed by real-time, interactive sessions, all of which are archived on the DOSITS website as a permanent resource. Webinars were conducted in 2015-2016 and 2018, with modules on the science of underwater sound, sound production and reception by marine mammals, effects of sound on marine mammals, sound production and reception in teleost fishes, and effects of sound on fishes. The 2019 webinar series focused on sound sources, including wind turbines, pile driving, seismics, echosounders, sonar, and shipping. In addition to the webinars, tutorials, instructional videos, and e-books have been developed to address content prioritized in the decision makers' surveys, such as science of sound fundamentals, hearing sensitivities, and updates on potential effects of underwater sound on marine animals. This presentation will provide an overview of the survey data and available DOSITS resources.

Assessing the effect of windfarms on marine mammals using point process pattern analysis

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The effect of operating wind farms on marine mammals still remains controversial, with different studies pointing to either positive, neutral and negative effects. We assess the impact during the operational phase of the windfarm "Butendiek" in the German North Sea on three different marine mammal species: Harbor porpoise (*Phocoena phocoena*), Harbour seal (*Phoca vitulina*) and Grey seal (*Halichoerus grypus*). Butendiek was selected for its isolation and good aerial coverage, which allow us to exclude interactions from other windfarms close by. The study was based on a series of 18 digital video aerial surveys (HiDef-technique) carried out between 2015 and 2018 and spread over different seasons of the year after the construction of the windfarm. We assumed spatial location of marine mammal occurrences as point processes to propose a model-based inference using a spatial log-Gaussian Cox process. The method adopts a flexible stochastic partial differential equation (SPDE) approach to model spatial structure in density and integrated nested Laplace approximation (INLA) for Bayesian inference. It allows simultaneous fitting of detection and density models and permits prediction of density at fine scale while specifically accounting for the local-scale dependence structure of the data. Results show a neutral effect of the windfarm Butendiek on the three analyzed species which supports previous observations in German waters.

The energetic cost of being a humpback whale and the consequence of losing energy to disturbance

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Few whale species have recovered to their pre-whaling numbers, such as the humpback whale (*Megaptera novaeangliae*). Found in all major oceans, they perform extensive seasonal migrations between high-latitude to low-latitude foraging and breeding grounds which exposes them to new anthropogenic threats that could affect energy intake or expenditure. Following previous models we developed for gray whales, we created a 2+ year breeding cycle bioenergetics model for humpback whales to determine the consequences of losing energy to disturbance. We considered various lactation costs: 50-100% when calves are 6mo. (calves start to forage)-10.5mo. (weaning). Total energy requirements for a 2-year reproductive cycle are 142.8-152.8 x 10^4 MJ. Total reproductive costs are 98.4-106.7 x 10^4 MJ. Our model predictions suggest that if a pregnant female loses 24-31% of the energy needed, she would not calf that year and if she loses 48-53% she will not calf for two consecutive years. Mortality could occur with a 50-55% energy loss. A resting female will not calf for two consecutive years with a 50-55% energy loss, and mortality could occur with a 52-57% loss. A lactating female at the foraging grounds (assuming previous energy losses prevented females from acquiring all energy required for lactation), would not calf the following year (resting) with a 13-9% energy loss. If she loses 16-12% she will wean her calf at a lower mass and could die if she loses 47-52%. Compared to gray whales, a greater mass allows for greater energy losses before losing a calf or dying. However, a smaller mass could sustain greater energy loss before weaning a calf at a lower mass. These findings need further exploration including other species and a greater mass range. Lastly, if we intend to maintain humpback whales de-listed conservation status, conservation measures should consider exposure to anthropogenic disturbance.

Integrated actions to conservation and management of the baleen whales in northwest Mexico

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More than 50% of the total baleen whale species in the world can be found in the northwest Mexico (NWM). This represents a privilege, but also responsibility over their protection and management. The success in the conservation of the populations of cetaceans depends on the knowledge about their biology, ecology, threats, as

well as their use. Here we present the results that were based on three components: 1) Biological, 2) Social and 3) Public Policies. Concrete and articulated strategies were proposed for the conservation of whales in the NWM. Component 1) For fin whales with satellite transmitters, areas and seasons for transit and feeding were identified within the Gulf of California (GC), and with the study of 10 steroid hormones, photo identification and historical records of sightings, an area and season of reproduction were identified. Regarding the threats for humpback, gray, and fin whales, information about entanglement and collision events with boats in the NWM was compiled. Component 2) Courses were given in ten fishing communities with the objectives of forming a network of trained observers in the identification and registration of cetacean species and their threats, as well as training the community in good whale watching practices. Finally, 3) Three proposals for Regional Protection Programs were prepared: a) Conservation of the Gray Whale, in its route of connectivity between two lagoons of winter aggregation in the Mexican Pacific, b) Conservation of critical habitats of the fin whale resident population, And c) Conservation of critical habitats for humpback, blue, fin and Bryde´s whales in the GC. In these programs, conservation areas and actions in the short, medium and long term were included, in order to ensure the conservation of whales that live or transit in the Northwest region of Mexico.

Social structure and demography of Blainville's and Cuvier's beaked whales at El Hierro, Canary Islands.

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Little is known about the social structure and demography of most of the 22 species of Ziphiids, in spite of the importance of these data to assess population dynamics and inform conservation management. Here we analyze a multiyear (2008-2018) photoID database of Blainville´s and Cuvier´s beaked whales from El Hierro (Canary Islands, Spain), where both species have year-round populations estimated in 103 (87-130) and 87 (78-106), with core use area subpopulations of 33 (CV 55%) and 39-53 (CV 36%) (Blainville´s and Cuvier´s, respectively). We observed mean inter-calf intervals of 3-4 years for "best breeders", but longer, up to 17 years, non-breeding periods in other females, and an apparent low survival of first year calves. Social analysis was performed with SOCPROG using 164 (Md) and 272 (Zc) group encounters where all whales were recognized, including 66 (Md) and 81 (Zc) identified individuals. Both species form small groups: Md (3,09 ±1,98) and Zc (1,98 ±1,25) and show a high estimate of social differentiation: S=0.847 SE=0.061 (Md) and S=0.709 (SE=0.038) (Zc). For both species the overall mean individual association index is low, but this is not homogeneous, as for some individuals it can exceed 0.5. In Blainville´s, males are rarely seen together in a group, females can have relatively long-term associations (25% probability of been seen together after 2 years), and females-male may form strong short-term associations (70% probability of a female by a male been seen together again after 30 days). In contrast, most stable associations among Cuvier´s are among males, which can remain together up to 7 years, while there are no long-term associations among females nor inter-sexes. Our results are consistent with previous descriptions of harem groups in Blainville´s beaked whales and loose fission-fusion societies in both Blainville´s and Cuvier´s beaked whales, but also unveil non-random long-term associations.

Evidence of sperm whale (Physeter catodon) lactation in Ligurian Sea: A breeding area in the North of Mediterranean Sea.

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The sperm whales (*Physeter catodon*) spend part of their life in matrilineal social units composed of females and their offspring. As odontocete, female differ from baleen whales in migrations, that do not typically involve a wide latitudinal shift, and in adult feeding throughout lactation, that lasts ~24-25 months. At birth and at weaning, the average body length is 4.05 m and 6.7 m respectively. Sperm whale calves suckle when performing a surface behaviour of repeated, short dives alongside an adult escort. Here, we report and analyse suckling behaviour of a sperm whale calf in Ligurian sea, at

the beginning of October, using aerial drone video footage on a group of three individuals – two adults and a calf. Aerial videos of two different lactating events have been taken using drone. Through aerial images, the calf estimated length is ~6 m and corresponds to about two third of the adult. In both videos, the sperm whale calf approaches the same nursing female, at distance of the mammary slits. Two bout of peduncle dives have been recorded. During these dives, ~13 s long each, the calf stays beneath the mother, remaining in a parallel and upright position, repeating several head butting, and taking one breath between peduncle dives. Afterward, the calf approaching from behind, rolls laterally to its left attempting to suckle through its mouth. In the final frame, some milk coming out from the mouth of the calf is clearly visible and confirms the suckling event. These observations strongly confirm that both solitary males and herd of females use Ligurian sea as foraging area, in their migration route within the basin. Furthermore, considering several sightings of herd of female with calves reported in the Pelagos Sanctuary, this latter could be another significant breeding area in the North West of Mediterranean Sea.

Population dynamics and structure of sperm whales (Physeter macrocephalus) in the Mediterranean Sea.

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The sperm whale (*Physeter macrocephalus*) has a cosmopolitan distribution. The Mediterranean sperm whale sub-population is classified as 'Endangered' according to the International Union for the Conservation of Nature. Even though this population hasn't faced the whaling age, it is currently threatened by other impacts which may cause direct mortality or stranding (i.e. ship strikes, debris ingestion, entanglement in driftnets, acoustic impacts). Previous genetic, acoustic and mark-recapture studies have indicated that this population is distinct from the North Atlantic population. Within the Mediterranean, the population structure is however unclear. Photo-ID data have shown three recaptures between the eastern and the western basins, though acoustic data revealed differences in the coda repertoires of social units between both basins. Our data from the Ligurian Sea to date, where 71 individuals have been identified, suggest that local recaptures are relatively infrequent in the western basin (30 in the Ligurian and 9 in the Tyrrenian Sea) in comparison with data for the eastern basin. Therefore populations may not be fully resident to local areas (based on photo-ID), but there is some evidence for divergence (based on acoustic data). Genetic differentiation among these basins has already been

confirmed for various dolphin and fish species. Here, we investigate population structure using ~5000-10000 single nucleotides polymorphism sites (SNPs) generated by restriction-site-associated DNA sequencing (RADseq). We have sequenced 160 samples from stranded and freeranging individuals, 34 samples from the eastern Mediterranean, 82 samples from the western Mediterranean and 44 samples from the eastern North Atlantic. We are analysing these data to address hypotheses about population structure, gene flow, demography, genetic variability and kinship within and among the analysed areas. These results will improve our knowledge of sperm whale demography and patterns of connectivity and are therefore essential for developing a more effective conservation management strategy for this endangered population.

Prospective impact assessment of offshore wind farm development on harbour porpoise distribution in the southern European North Sea.

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In the North Sea, marine renewable energy projects, particularly offshore wind farms (OFWs), have undergone an intense development with potential impact on marine megafauna, including changes in behaviour or foraging patterns. The southern North Sea concentrates both intensive anthropogenic activities (*e.g.* shipping, OFWs) and high densities of harbour porpoises (*Phocoena phocoena*). Particularly, the number of wind farms is planned to at least double in the coming years (from 6 to about 14), stressing the need to mitigate the impact of human activities. We conducted 6 repetitive aerial surveys in the southern North Sea between April 2017 and May 2018 with the aims of (1) predicting monthly distribution and abundance of harbour porpoise, (2) assessing the relationship between porpoise and OFWs, and (3) investigating the potential impact of new OFWs to be implemented in the study area. Highest abundances were estimated in spring (25,000 individuals [5,700-52,200]) and the lowest in summer (2,500 individuals [970-4,200]). Porpoises exhibited a year-round avoidance of OFWs, and were mostly found at distances from them higher than 40 km. Based on this empirical correlation, we explored the effect of prospective OFWs in the study area on a monthly basis, and predicted that the overall porpoise abundance would be lower when these OFWs will be operating. This diminution would probably be linked to the avoidance of the new OFWs forcing porpoises outside the study area. Such an approach has the advantage to prospect simultaneously the cumulative risk impact of multiple OFWs (either operating or in development) in a rather small area. This suggests that risk assessment considering all OFWs in development rather than risk assessment focused on single OFW would be relevant for proactive conservation, particularly to anticipate or mitigate the effects of anthropogenic disturbances at a population scale.

Demographical analysis of the endangered population of the harbour porpoise from the Sea of Azov using a Bayesian-based model.

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There is a separate population of the harbor porpoise in the Sea of Azov which is distinct for its morphology and life history. Here a demographical study is conducted based on the sample of porpoises which died in 2000-2013 in the southern Azov. Demographic parameters and abundance trends were assessed using the Bayesian inference and Syler's model with bycatch as mortality risk (the procedure by J. Moore). The abundance of Azov porpoises was consistently declining; as estimated here, in 2001-2012 it declined more than twice, from 13,500 to 6,000. Natural growth rate was within 2-4%, with high birth and natural death rates and high generation turnover rate; the greatest mortality rate falls on the first year of life. The population is endangered due to incidental bycatches in fishing gears. Bycatch was the greatest mortality factor. It led to annual decline in abundance by 27% in some years, because of mortality rise and great losses in birth rate due to takes of individuals which finally did not contribute to reproduction. Bycatch was shown to affect primarily juvenile and subadult animals: at the age of 1-5 years bycatch as the mortality factor was greater than all the natural factors. Notably, in 2000-2002 the population was already stressed under anthropogenic impact, then, in 2006-08, bycatch decreased, and the population stabilized. By 2011, the bycatch rate was lower than in 2000-2002; however, the population was more depleted than a decade before: life span declined (especially, in males), and mortality increased. The birth rate somewhat increased during the observation period, as follows from the model data; however, it did not

lead to recovery of the population. Bycatch impact is irregular in mid-term perspective; however, it is extremely great, and the risk of extinction is high for the Azov population.

My enemies' relatives are my friends: An unlikely relationship between killer whales, dolphins, and porpoises.

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Despite the obvious risk to an animal approaching their potential predator, so called "predator inspection" behaviours have been described for several vertebrate species. Prevailing hypotheses suggest predation risk is offset by the information prey acquire about their predators during these encounters. Here, we describe an apparent variant of the predator inspection paradigm: dolphins and porpoises associating with members of a fish-eating killer whale ecotype (RKW) that is sympatric with, and closely resembles, a mammal-eating ecotype (BKW). We have observed this behaviour more than 50 times over the course of 34 field seasons in British Columbia, and examined it comprehensively in drone footage taken in 2018. Here, we describe consistent features of these observations, which involved Pacific white-sided dolphins (PWSD) and/or Dall's porpoise (DP) approaching groups of resting, travelling, or foraging RKW – swimming alongside them for periods ranging from minutes to days. Aerial recordings allowed us to rule out the possibility that PWSD and DP are hydrodynamically "hitching a ride" and – along with vessel-based observations – suggests this association is not strictly social, as RKW appeared to avoid the two species – briefly chasing them at times. PWSD and DP often approached RKW while they were foraging or prey-sharing, therefore it is possible that they occasionally obtain prey scraps. However, we hypothesize that the primary advantages of this association are that PWSD and DP gain protection from ambush attacks by BKW and allows them to acquire information about the agility, speed, and behaviour of killer whales. We present four lines of evidence in support of this hypothesis: (1) All four species are common in the study area; (2) BKW do not associate with RKW, and actively avoid them; (3) Predation of both PWSD and DP by BKW often occurs in the absence of RKW; (4) RKW very rarely harm either species.

Entanglements in the 'Nationally Critical' population of coastal New Zealand orca (Orcinus orca).

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The New Zealand coastal population of orca (killer whales, *Orcinus orca*) is classified under the Department of Conservation (DOC) Threat Classification System as 'Nationally Critical', the highest category possible. This classification is based on, *inter alia,* their low population number (fewer than 200 individuals) and the wide range of threats they face including critical habitat destruction, pollution bioaccumulation, boat strikes, strandings and fisheries interactions which include shootings as well as entanglements. The latter is of particular significance due to the high number of events with least 21 orca (of both sexes and all age-classes including adults, juveniles and calves) becoming entangled since 1979. Entanglements have occurred in commercial fisheries gear, including gill and trawl nets, long-lines and cray-pot lines, as well as likely entanglements with private fishing gear from pots, rods and/or handlines. The outcome of these entanglements included seven confirmed deaths, another nine whose fate remains unknown (due to poor documentation) and only five who were actively disentangled and released. The DOC, although legally mandated to protect New Zealand marine mammals, did not participate in any disentanglements and instead the public and volunteer entanglement response networks responded and released them. Only one orca was photo-identified during the disentanglement process and she has been resighted on numerous occasions over the five year period since her release. To minimise entanglements of orca, easily-applied mitigation options are presented and these methods may also help reduce entanglements of other cetaceans around New Zealand. In addition to implementing mitigation options it is vital that the DOC work with the volunteer entanglement response networks to improve disentanglement rates for this Nationally Critical population to ensure its viability.

Bottlenose dolphin (Tursiops truncatus) in the water of Ischia Island (Gulf of Naples, Italy): A long term analysis on distribution, habitat use and photo-Identification.

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This study presents data on a bottlenose dolphin (**Tursiops truncatus**) local population monitored in the waters off Ischia Island (Gulf of Naples, Italy) over a fifteen-year period (2004-2018). Data were collected during the Ischia Dolphin Project, an ongoing long-term research program on cetaceans. Surveys were conducted five days a week from May to October. Few additional outgoings were made in winter and spring.

1,186 daily surveys were performed, during which 58,332.47 km were covered. There were 91 encounters in which bottlenose dolphins were followed for a total of 877 km and 156 hours. Group size ranged between 1 and 130 animals (mean 37; SD±33.23). 79% of the observed groups included immature individuals (calves and/or juveniles n=72), with most of these including calves (n=54). Dolphins were mainly distributed in coastal waters (range 9.63-855.78; average 139.75; SD±187.42), with the highest concentration in the area NW of Ischia. Preliminary photo-identification analysis was performed on 68 sightings, resulting in cataloguing 207 individuals. 108 individuals (33 females) were resighted during years (range 2-10yr). 71 behavioural sequences (>40') were analyzed (mean duration 121', range 41-417). Dolphins were mostly seen feeding (54%) and travelling (44%). Socializing was recorded in 21% of the encounters, while milling (8%) was the least observed behaviour.

The data here presented show that the waters around Ischia Island represent a feeding area, as well as a calving and nursery area for the bottlenose dolphin local population. The study area has been classified as a Marine Protected Area ("Regno di Nettuno" MPA) and recently, the area has been recognized as Important Marine Mammals Area (IMMA) by the IUCN, with common dolphin, bottlenose dolphin and fin whale as qualifying species. However, despite the severe anthropogenic pressure (overfishing, traffic, pollution) in the area, no management action aimed at preserving the local ecosystem was implemented.

Calibrating Unoccupied Aerial System (UAS) photogrammetry to derive delphinid population demographic parameters.

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Understanding the dynamics of cetacean populations is important to optimally manage these species. Healthy populations exhibit stable age structures, while deviances from such indicate unstable populations. Quantifying the age structure of free-ranging cetacean populations has previously required years of intensive survey effort. However, new technologies allow for the development of novel approaches to accurately and efficiently quantify population age structure and growth. Such parameters may provide early insights into whether there may be cause for concern for certain populations. Aerial photogrammetry has become common practice in cetacean surveys, and emerging Unoccupied Aircraft Systems (UASs or 'drones') have facilitated the collection of such imagery. To date, studies have not ground-truthed UAS-derived morphometric measurements of cetaceans with their true sizes and few studies have collected aerial photogrammetric measurements of delphinids. This study aims to compare physical and UAS-derived measurements (length, girth, width and volume) of 12-18 bottlenose dolphins *(Tursiops truncatus)* and one false killer whale *(Pseudorca crassidens),* all of known age, housed at Sea Life Park Hawaii and Dolphin Quest Oahu, Hawaii. Two different UAS platforms will be flown consecutively over each individual at five altitudes. Individuals will be measured when a) lying flat (not curved) at the surface to assess length and width and b) performing a natural surfacing to account for body curvature. The objectives of this study are to 1) quantify the precision and accuracy of aerial photogrammetry in assessing these measurements, 2) infer individuals' age-class based on their length and 3) cross-calibrate UAS-derived measurements. While sampling is currently ongoing, we believe this innovative and non-invasive methodology will provide precise information on UAS-derived length measurements and represents the first step in using UASs to assess demographic parameters of free-ranging delphinids.

Impact of herring spawning events on killer whale migratory behavior.

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Killer whales*(Orcinus orca)* are a widely distributed marine mammal. These toothed cetaceans are top predators that typically specialize on specific prey types. While Antarctic and Pacific killer whale prey has a strong influence on their respective movement patterns, little is known about the seasonal movements of the North Atlantic killer whales off the Norwegian coast. Visual observations and photo identification have been used to track the movements of Norwegian killer whales, but effectively limit monitoring to near-shore and inner-fjord behaviors. Bio-telemetry has the potential to reveal offshore behaviors and has been successfully used to track these whales. Along the Norwegian coast killer whales are believed to be strongly associated with the Norwegian Spring-Spawing(NSS) stocks of Herring (*Clupea harengus*). To evaluate the impact of herring spawning events on Norwegian killer whale migratory behavior we analyzed data from over 30 individuals tagged with ARGOS transmitters from November to February at three different herring overwintering areas; 2000-2001 in Tysfjord/Lofoten, 2015-2016 outside Tromsø and 2017-2019 outside Skjervøy. We cross-correlated bio-telemetry data with annual standardized NSS herring stock assessment that identified spawning hotspots to evaluate the impact of spawning events on killer whale migratory behavior. Killer whale behavior was strongly associated with herring spawning hotspots. Annual variations in the location and magnitude of these hotspots were also reflected in killer whale movements. After the spawning events, some killer whales followed the herring to their summer feeding grounds in the Norwegian Sea, while others entered the Barents Sea, reaching as far as the ice edge off Novaya Zemlya. Our results confirm the importance of NSS herring and its phenology for Norwegian killer whales. Furthermore, bio-telemetry tools allowed us to document previously unobserved offshore herring-associated behaviors.

Are near-distance seal scarer effects as strong as the effects of offshore piling noise on harbour porpoise (Phocoena phocoena)?

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To protect its only resident cetacean species in German Waters from noise damage, offshore wind park operators are required to acoustically deter harbour porpoises (*Phocoena phocoena*) out of the impact zone prior to pile driving. But what if the deterrence measures stress porpoises disproportionally and are as disturbing as noise-mitigated piling? We analysed porpoise detections from up to 3 hours before deterrence until 3 hours after piling for six offshore wind farms constructed from 2014 to 2016 in the German Bight. Seal scarers were used as acoustic deterrent devices. All pilings were noise-mitigated and sound levels (SEL_{05}) were below 160dB at 750m distance from pile driving locations, which is the German noise-protection threshold. We compared porpoise detections at 750m and 1500m distance to pile driving locations of 302 piling events. C-POD data were split into the phases of before piling, during deterrence, during piling and after piling. We analysed data using a Generalised Linear Mixed-effects Model (GLMM), accounting for project- and foundation-specific variance and temporal autocorrelation of porpoise click detections. At 750m, deterrence was close to 100% effective as generally no detections were recorded then and during subsequent piling. At 1500m however, the probability of porpoise detections was higher than at 750m, although still significantly reduced by 36-41% during deterrence and piling, compared to the few hours before deterrence. The effects of deterrence and piling activity were statistically not distinguishable. This raises the question on the effect strength of seal scarers on harbour porpoises with respect to noise mitigated piling as in distances of 1500m the sound levels were generally below the threshold set to avoid hearing damage. In literature, seal scarer deterrence effects were found up to 7km from construction sites. Is the displacement effect by seal scarers in relation to disturbance by pile-driving noise stronger than necessary?

Aggressive behaviors of adult male Atlantic spotted dolphins: Making signals count during intraspecific and interspecific conflicts.

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Sympatric species exist together in the same immediate habitat and are often in competition for resources, which can result in aggressive interactions. Some species, including chimpanzees and noisy miners, have been known to exhibit behavioral plasticity by altering their aggressive behavior (during both *intraspecific* and *interspecific* encounters) based on their opponent. Atlantic spotted dolphins (*Stenella frontalis)* and bottlenose dolphins (*Tursiops truncatus*) are two sympatric species resident to the northern Bahamas. We examined whether groups of spotted dolphins were behaviorally plastic during aggressive behaviors. We described and compared the aggressive behaviors used by groups of adult male spotted dolphins during *intraspecific* aggression and *interspecific* aggression with bottlenose dolphins. Between the years 1991-2004, twenty-two aggressive encounters (11 *intraspecific*, 11 *interspecific*) were behaviorally analyzed. Twenty-four specific aggressive behaviors termed behavioral events, further grouped into three behavioral classes, were examined throughout these encounters. Both similarities and differences in the use of the behaviors occurred during *intra*- and *interspecific* aggression. Within the Pursuit behavioral class, chasing (a behavioral event) was used significantly more during *interspecific* aggression. Within the Display behavioral class, open mouth displays, were used significantly more during *intraspecific* aggression. Lastly, the Display behavioral class was used significantly more than the Contact behavioral class only during *intraspecific* aggression. Spotted dolphins changed their aggressive behavior by using a more energy-intensive behavior and more overt communication signal, the chasing behavioral event, and less open mouth displays during *interspecific* aggression. Spotted dolphins may change their behavior during aggressive encounters with the bottlenose for potential mating opportunities or to avoid physical harassment. The dynamics of sympatric aggression may provide insight into resource use and may be useful to monitor for any future changes in the environment.

Recent insights into the susceptibility of harbor porpoises (Phocoena phocoena) to airgun exposures

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To understand the effects of airguns on harbor porpoises, exposure experiments were carried out with captive animals exposed to down-scaled airguns. To quantify temporary threshold shift (TTS) caused by airgun-exposure and the subsequent hearing recovery, the hearing of one harbor porpoise was tested by means of a psychophysical technique. TTS was after exposure to 10 and 20 consecutive shots fired from two airguns simultaneously (cumulative sound exposure level, or SELcum: 188 and 191 dB re 1µPa^{2}s) during a first set of experiments. Although most of the airgun's acoustic energy was below 1 kHz, statistically significant initial TTS$_{1\text{-}4}$ (1-4 min after sound exposure stopped) of ~ 4.4 dB occurred only at the hearing frequency 4 kHz, and not at lower hearing frequencies (0.5, 1 and 2 kHz). Recovery occurred within 12 min post-exposure. The study indicates that frequency-weighted SELcum was a good predictor of low levels of TTS. In a second set of experiments with the same animal, but with up to 4 airguns no TTS occurred both at 2, 4 and 8 kHz, even though the exposure levels were higher (SELcum up to 199 dB re 1µPa^{2}s). It is not clear why no TTS was measured during the second experiment, but possibly the porpoise was reducing the received SEL by self-mitigation. Opportunistic observations of animal behavior during these experiments indicated that behavioral response to the sound differed between two individuals tested. In addition, both animals showed no response to airgun exposure when a screen of encapsulated air bubbles, which effectively reduced the high-frequency (> 200 Hz) content of the airgun sound, was placed between the airgun and the porpoises. The results of these studies highlight the importance of the frequency content in driving both auditory and behavioral responses, as well as the variability in behavioral susceptibility between and within individuals.

Estimating calf production of Cook Inlet beluga whales using an Unmanned Aircraft System and photogrammetry

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The endangered Cook Inlet (Alaska) beluga whale is a genetically distinct, geographically separated population that declined rapidly in the 1990s to a small population size, with no sign of recovery since. Although the abundance and trend of the Cook Inlet beluga population is monitored, little is known about vital rates that could help explain the lack of recovery. In 2017 we initiated a project using an unmanned aircraft system (a hexacopter) launched from a small boat to take high-resolution aerial photographs of beluga whales in Cook Inlet. A gimbaled laser altimeter on the aircraft provides precise estimates of altitude, which allows photogrammetric methods to be used to measure whales. The primary objective is to identify newborn calves to estimate an annual index of calf production, to ultimately determine whether this population exhibits a reproductive rate typical of that expected in a healthy population of belugas. The opaque waters of Cook Inlet prevent measurement of total body length; instead we measure relative body length (the distance from the blowhole to the dorsal ridge). In the first field season we conducted a total of 67 flights (11 hours of flight time) over 11 encounters with beluga whales, resulting in a total of 661 photographs of beluga whales that are measurable. Precision of the length estimates is sufficient; the average difference in relative length estimates of the same whale from multiple images is 2.8cm (range 0.1-7.4). Preliminary measurements indicate newborn calves (mean 57.7cm, range 52.9-65.2cm) can be unambiguously distinguished from presumed (from blue-gray color) one-year old calves (mean 79.4cm, range 71.3-88.1cm), showing photogrammetry can be used to identify young-of-the-year and estimate annual calf production. Early growth in neonates is also seen; neonatal calves with visible fetal folds (55.2, 95%CI 54.2-56.2) were significantly smaller than neonatal calves without visible folds (60.8, 95%CI 58.2-63.3).

Decadal and regional- scale response of the North-East Atlantic cetacean community to environmental change

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Meteorological and oceanographic changes influence marine ecosystems. Warmer temperatures, altered ocean currents and increased storm frequencies directly impact lower trophic levels (plankton, fish and cephalopods). For instance, lower trophic levels could change distributions to coincide with preferred temperatures whereas changes in vertical mixing and nutrients may affect primary productivity and biomass. These changes at lower trophic levels will have indirect impacts on cetaceans by altering prey availability. Predicting future impacts of environmental changes on cetaceans requires an understanding of how previous changes have already impacted communities in vulnerable regions. Such analyses demand information on species prevalence at decadal and basin-scales. This study uses 2.68 million km of at-sea aerial and vessel surveys in the North-East Atlantic between 1985 and 2018 to identify changes in encounter-rates with species, and investigate associations between changes and environmental variables. Results indicate a general increase in warm-water species alongside decreases in cool-water species. For example, common dolphin *Delphinus delphis* and striped dolphin *Stenella coeruleoalba* have expanded whilst white-beaked dolphins *Lagenorhynchus albirostris* have declined. These changes in encounter rates were correlated with long-term trends (+5yr) in regional temperature, the Atlantic Multi-decadal Oscillation (AMO) and North Atlantic Oscillation (NAO). However, more complex patterns and relationships with environmental changes were also revealed. For instance, harbour porpoise *Phocoena phocoena* have increased in the southern but decreased in the northern North Sea. This suggests that responses to environmental changes are not always correlated to long-term trends in temperature or indices *per-se*, and that scale-dependent responses are sometimes present. It is proposed that an increased understanding of trophic links between cetaceans and prey could explain and predict these variations in responses to environmental changes.

Seven years intensive pile driving in the German Bight without consequences on Harbour porpoises abundance?

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Harbour porpoises (*Phocoena phocoena*) react to pile driving noise of offshore wind farms by temporally swimming away from the noise source, which has been demonstrated in several studies. However, long-term effects on porpoise abundance still remain speculative and are predominantly predicted with models, whose assumptions are based on findings of short-term effects of single wind farm projects. In our study we use data from passive acoustic monitoring devices (porpoise detectors: C-PODs), which were deployed from 2010 to 2016 to detect deterrence effects of the 19 wind farm projects erected in the German Bight (including adjacent Dutch waters) during this period. We combine C-POD-data from 130 monitoring locations with 79,384 recording days in our analyses to assess long-term population level effects. Despite all pile driving activity, we found that porpoise detections increased from 2010 to 2016 in the German Bight. However, this trend was neither monotone over the years, nor uniform throughout the study area. The increase was strongest in the south-eastern part of the study area whereas porpoise detections even decreased in the central German Bight. Annual changes in porpoise detections could, however, not be related to pile driving activity in the area. As such, the pile driving activity in the central part of the German Bight was highest between 2011 and 2013. However, the strongest decrease in porpoise detections occurred after 2013. In other parts of the study area, porpoise detections changed seemingly independent of piling activity within that region. We thus can currently not prove a negative influence of pile driving activity on harbour porpoise abundance in the German Bight. This suggests that environmental factors are, up to date, the predominant factors influencing porpoises on population level more strongly than the generally noise-mitigated pile driving activities in the German Bight.

Echoes from harbour porpoise echolocation signals bouncing off gill nets propagates larger distances than previously assumed

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Harbour porpoises (Phocoena phocoena) are caught in large numbers in gill nets. Even though acoustic pingers and changes in fishing practices have reduced a previously enormous bycatch, drowning in fishing nets is currently the largest single anthropogenic factor known to kill animals, and the only known factor having a significantly negative effect on porpoise populations. Therefore, it is important to understand why porpoises are entangled in the gill nets. Porpoises emit high-frequency echolocation clicks and have the most sensitive ears known in the animal kingdom. Even so, previous calculations have pin-pointed that they can only detect gill nets at distances shorter than 5-10 m. By measuring the echoes by simulated porpoise clicks on gill nets up to distances of 50 m in shallow waters and in a measurement tank, this study shows that previous estimates of the detection range of porpoises are seriously underestimated. The underestimation is well explained by the choice of transmission loss model used, in previously studied assumed to be spherical, but in this study (in line with theoretical deduction) shown to be cylindrical. This means that porpoises can probably detect gill nets at distances of 50 or more meters. This has large implications for our understanding of the reasons why porpoises get entangled in gill nets, and also for the design of appropriate changes in the currently used gill nets to avoid further bycatch.

Tracking and measurement of marine animals using unmanned aerial vehicles

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Unmanned aerial vehicles (UAVs) enables researchers to gather images and video footage of marine animals like porpoises and seals. The value of these data for researchers can be increased by augmenting the data with information about the flight saved by the UAV. A flying UAV stores information about its position, altitude and orientation of the camera to a logfile.
By combining this information about the UAVs

flight pattern with observations in videos acquied during the flight, it is possible to determine the location of objects on the water surface in real world coordinates and also the distance between objects
in the water surface. To assist this process a computer program has been developed. The program can load a video and the associated log file from the UAV and it allows the user to annotate locations and measure distances along with the water surface.
The output from the program is a text file with timestamps, GPS coordinates and
associated lengths of each of the annotations.
By utilizing this information it is possible to analyze the movement of one or more marine animals in a recorded video; it is also possible to quantify the length and width of the observed animals. The accuracy of the determined position is limited by the used global navigation system and can under typical circumstances be determined within 5 meters. The relative accuracy of the determined lenghts is related to the uncertainty of the the altitude estimates of the UAV, and will under typical circumstances have a magnitude of 5%. The presentation describes the principles behind the developed program, investigates
the uncertainties that is to be expected by employing this approach and gives some basic guidelines for data acquisition using UAVs to ensure reliable measurements.

Reproductive success delays molt and increases thermoregulatory demands in the Weddell seal.
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Energy conservation is a key consideration for all animals, with daily resting periods offering the opportunity to relax in anticipation of the next activity bout. For semi-aquatic mammals, daily haul-outs must occur between foraging bouts, which usually requires animals to haul-out on sand, rock, or ice that is spatially separated from prey resources. In addition, the duration of the daily haul-out periods may reflect the impact of physiological constraints and environmental conditions on energetic balance. Weddell seals (*Leptonychotes weddellii*) undertake daily haul-outs on Antarctic sea-ice in order to rest, reproduce and molt. However, there are two factors that may increase the duration and scheduling of haul-out periods: cold air temperatures and wind can increase heat loss, and this can be exacerbated when skin is perfused during the annual molt. To assess how physiological (reproduction/molt phenology) and environmental (weather conditions) factors influenced haul-out durations and corresponding in-air heat flux, time activity budgets of 55 adult females were measured across the austral summer. Females who skipped reproduction in the early summer hauled-out for longer durations and more frequently during sunny afternoons, whereas post-reproductive females spent less time hauled-out, and showed no diel preference in haul-out timing. Furthermore, because post-reproductive females molted later in the summer, in colder ambient conditions, they exhibited significantly higher in-air calculated heat flux across the active molting season compared to skip-breeders which hauled-out and molted in optimal summer conditions ($p < 0.001$). Overall this indicates there is an added thermoregulatory cost associated with reproduction that is not often considered when quantifying reproductive energy costs. This research address how behavior can be used to inform energy budgets for polar pinnipeds in a changing climate, and can further aid in understanding how haul-out requirements during molt of Arctic species may be further impacted by limited ice haul-outs and terrestrial predation.

UK recommendations to reduce marine mammal disturbance from marine tourism.
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Commercial marine mammal watching is growing in popularity in the UK and together with a rise in water-based recreational activities occurring around the coastline, appears to be causing an increase in disturbance incidences of cetaceans and seals. The EU Habitats Directive provides some protection from harassment or disturbance of marine mammals. However, other than in Scotland, where legislation exists to protect seals at designated sites, there are no specific legislation, regulation or licence requirements for commercial wildlife watching operations or recreational activities to prevent marine mammal disturbance. Voluntary guidelines and codes of conduct do exist and there is a national scheme (WiSe) which aims to promote responsible wildlife watching through training, accreditation and awareness-raising of boat operators. However, none of

these measures are required to operate a vessel nor enforceable by law.

The UK Governments and conservation agencies, together with NGOs and Wildlife Crime enforcers, recognise that incidences of disturbance are increasing, that awareness of what causes disturbance is generally low and there are few management measures to protect marine mammals from these activities. The UK has therefore developed a 'Dolphin and Porpoise Conservation Strategy', with a range of action plans, one of which concerns marine tourism. The aim is to review options for management measures including regulations, licensing and disturbance monitoring. Here we review approaches from elsewhere in the world to provide recommendations of possible management measures, but also highlight the challenges that will need to be addressed to ensure effective management and protection of marine mammals from disturbance in UK waters.

A reserve network of translocation brings hope and offers opportunities for the recovery of the critically endangered Yangtze finless porpoise

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Since the first five individuals of the Yangtze finless porpoise were translocated to the Tian-e-zhou oxbow in 1990, this reserve has seen great adaptation of these animals and steady population growth. This successful experience has led to a reserve network with two more translocation populations established. Exchange programs among these populations have been implemented aiming to maintain the genetic diversity. Now with more than 120 individuals, this reserve network provides insurance against the threat of extinction and provides opportunities for reintroduction to supplement wild populations. We hope this work will shed light on the conservation of other endangered aquatic animals.

Sounding the alarm: Passive acoustic monitoring show marine protected areas in Hong Kong, SAR, China are insufficient to conserve the declining Indo-Pacific humpback dolphins (Sousa chinensis).

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Indo-Pacific humpback dolphins (*Sousa chinensis*) of Hong Kong's waters are declining due to considerable habitat loss resulting from massive developments in coastal waters. As compensatory measures, two marine protected parks (Sha Chau & Lung Kwu Chau Marine Park, SCLKCMP, and Brothers Island Marine Park, BMP) were established in 1997 and 2016, respectively. However, the effectiveness of these marine parks is unknown. In 2013-14 (prior to a mega-development project), CPODs were used to obtain some initial passive acoustic monitoring data at two sites, one each in the SCLKCMP and BMP. Towards the end of one mega-project and the beginning of another in 2017-18, CPODs were deployed again at the same two sites. In 2013-14, 120.10 and 128.22 logged days of data were obtained from the SCLKCMP and BMP sites, respectively. In 2017-18, CPODs obtained about the same number of logged days on the same dates/times for the two sites as in 2013-14. Overall, daily detection positive minutes (DPMs) declined significantly from 2013-14 to 2017-18 (Mann-Whitney $U=21368.5$; $p<<0.0001$). While DPMs for the two sites were not significantly different from each other in 2013-14 ($U=7770.0$, $p=0.869$), SCLKCMP site had more DPMs than the BMP site in 2017-18 ($U=92.0$, $p<<0.001$). Daily DPMs at the BMP site declined to near zero DPMs (Wilcoxon $T=73.5$, $p<<0.00001$) but increased at the SCLKCMP site ($T=2309.5$, $p<0.0005$), however, not to the same level as the BMP decrease. Although some displaced dolphins likely increased their utilization of SCLKMP waters (where impacts are lower), the tiny marine parks used as mitigation measures for large losses of habitat are clearly failing to prevent the dolphin decline in Hong Kong's waters. Much more habitat needs to be protected and prior to further development to ensure the dolphin declines can be stopped and reversed.

Estimating abundance and the effects of ocean conditions on survival and natality in steller sea lions (Eumetopias jubatus) using an integrated population model.

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Integrated population models (IPMs) that combine disparate data sources can improve the precision of abundance estimates and demographic rates through the simultaneous analysis of the state of a population and the dynamic processes that underlie that state. Despite the utility of this approach particularly for data-limited species or situations, few IPMs have been developed for marine mammals. Here we present a Bayesian IPM for the western distinct population segment of Steller sea lions (*Eumetopias jubatus*) that combines aerial survey data with mark-recapture data from 2000-2017, thereby allowing robust inference about intrinsic characteristics and ecosystem features influencing age-specific survival and natality over a longer period than has been examined to date. Though the decline and subsequent recovery of Steller sea lions has been studied extensively, the influence of oceanographic conditions on demographic rates has not been explored and aerial survey data have been used at the coarser level of pups versus non-pups rather than a more robust age-based approach. The hierarchical model framework facilitates the inclusion of environmental data (e.g., upwelling and large-scale oscillations), individual characteristics (e.g., pup weight and natal region), and survey features (e.g., sampling intensity) when modeling both the state and observation processes that give rise to abundance data. The multi-event mark-recapture component of the IPM was evaluated using Bayesian model selection approaches, identifying small but notable effects of pup weight and ocean conditions on pup survival and natality. This model provides much-needed updated abundance estimates, improves predictions of population viability, and advances efforts to identify factors driving regionally-divergent abundance trends. Examining the relationship between predators and their environment through one of the first IPMs for an otariid species informs efforts to quantify the regional impacts of human activities and provides new insights that are foundational to ongoing conservation and management with respect to future climate variability.

Spatio-temporal distribution of pygmy and Antarctic blue whales in central New Zealand, via passive acoustic monitoring

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Passive acoustic monitoring provides an effective method for studying visually-cryptic, but acoustically diverse, vocal organisms. Two sub-species of blue whales, pygmy and Antarctic, co-occur around New Zealand. Visually, the two sub-species are difficult to distinguish in the field, however, songs produced by males are markedly different and can be used for sub-species identification. Acoustic data were collected from four recorders placed in the Cook Strait region, between New Zealand's North and South Islands, during 2016 and 2017, to investigate the spatial and temporal distribution and overlap of the two blue whale sub-species.

Pygmy blue whale song units were recorded throughout the region during all months of recording. Detection of these sounds peaked between March and May (58% of all units were detected in this period), and detections were fewest during September and October (austral spring). A total of 85% of pygmy blue whale song units were detected to the west of Cook Strait (South Taranaki Bight). At this westerly recorder, a large number of feeding-associated calls (not sub-species specific) were also detected, suggesting blue whales could use the area for foraging.

Detection of Antarctic blue whale songs peaked from June to August (92% of calls), with a smaller peak during October (7% of calls), likely indicative of northbound and southbound migration, respectively. The period between June and October is presumed to be the breeding season, and fewer calls were detected with poor quality suggesting breeding occurred away from the acoustic recorders. A vast majority (77%) of Antarctic blue whale song units were detected to the east of Cook Strait, suggesting that migration past New Zealand occurs over deep water.

During Antarctic blue whale migration, the two sub-species are sympatric in New Zealand waters, but with different residency patterns.

Potential resource competition between narwhal and beluga in northern Hudson Bay, Canada

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Narwhal (*Monodon monoceros*) and beluga (*Delphinapterus leucas*) are the only two extant monodontid species and both have an Arctic distribution. The species are often found in different areas, and news of a single narwhal observed travelling with a pod of beluga in the St. Lawrence River sparked worldwide attention. However, both species regularly occur in northern Hudson Bay in the central Canadian Arctic during the summer months. Little is known about how they interact with one another and whether they compete for prey or specialize on different prey during this seasonal overlap in their home range. To investigate potential interspecific competitive pressure, we estimated 1) range and abundance by conducting an extensive aerial survey of the area in August 2018 and 2) the extent of dietary overlap between both species through stable isotope (SI) analysis in skin, and fatty acid (FA) analysis in blubber samples. Aerial observations revealed narwhals and belugas travelling in pods only a few meters apart, and distance analysis showed higher narwhal density and abundance in the area. Statistically significant overlap in SI and FA measures between the two species suggests they compete for similar prey resources. Intraspecific competition with a high density of beluga in western Hudson Bay may drive some belugas into northern Hudson Bay, where they encounter narwhal and increased interspecific competition for prey. Since this area has a lower whale density overall, beluga may face less competitive pressure by distributing further north. Whale density, prey availability and distribution, and philopatry all contribute to defining regions where narwhal and beluga can coexist. Interspecies competition may drive niche partitioning between narwhal and beluga over time.

Behavioral response function for Cuvier's beaked whales on a Navy training range

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The behavioral response to mid-frequency sonar has been documented for a variety of cetacean species, with impacts including increased swimming speed, travel away from a location, changes in orientation or group synchrony, cessation of resting or vocal behavior, and stranding. Additionally, multiple species (Blainville's and Cuvier's beaked whales, killer whales, blue whales, and sperm whales) have shown impacts to foraging behavior. For beaked whales, passive acoustics allows for the quantification of foraging impacts by examining changes in the distribution of detections of echolocating foraging groups during sonar activity, as was demonstrated for Blainville's beaked whales, to develop a behavioral response function (BRF). Here we will develop a BRF for another species of beaked whales, Cuvier's beaked whale (*Ziphius cavirostris*), found on the US Navy's Southern California Anti-Submarine Warfare Range (SOAR). Previous analyses at SOAR have demonstrated that passive acoustic detections of active foraging groups declined significantly during sonar training events, but returned to pre-event levels within hours of the sonar ending. Additionally, data from tagged whales showed that the time between foraging dives increased as proximity to sonar events decreased. To understand the overall impact of sonar on foraging at SOAR, we modeled received levels during actual sonar training events, using the Navy Acoustic Effects Model (NAEMO), across a variety of sonar training events, with different types of mid-frequency sonar sources, to cover the variability in training events that occur on this range. Foraging activity in time periods without sonar were used to estimate baseline foraging level. A generalized additive model was used to model the presence or absence of foraging groups on each hydrophone as a function of the sonar received level, and hence a BRF. Comparison to the BRF for Blainville's beaked whales in the Bahamas will be discussed.

Environmental pollution impacts lipid metabolism and adipogenesis in polar bears

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Polar bears annually undergo a physiologically stressful fasting period, during which they must maintain optimal control of their metabolism if they are to survive. However, their ability to store energy for survival is challenged by the decline of Arctic sea ice. This has been linked to negative impacts on survival and reproduction, due to longer periods of fasting and a greater dependence on physiological processes.

The polar bears physiological ability to respond to this challenge may also be limited. As apex predators in the Arctic, with large lipid stores, they are exposed to significant environmental pollution. Over 90% of their body burden of pollutants are found in white adipose tissues, thus adipose tissue is at special risk for toxic effects. White adipose tissue consists mainly of adipocytes, with the primary function of storing lipids in periods of excess energy and mobilising lipids during energy deprivation. Results from correlative field studies and *in vitro*studies already indicate that pollutants disturb polar bear lipid metabolism. However, the mechanisms by which this occurs remains elusive.

Thereby we studied the effect of pollutants on adiponectin levels and the expression of two miRNAs important for adipogenesis (miR-27a and miR-130) in n = 112 polar bear blubber biopsies obtained from populations inhabiting Svalbard, Norway. We provide evidence that pollutants decrease the expression of these miRNAs and limits adiponectin levels.

Modulation of these miRNAs away from their equilibrium (both overexpression or under expression) has been shown to limit adipogenesis in mammals. Thereby, exposure to pollutants may be limiting polar bears ability to store and remobilise lipids when needed, contributing to decreased survival and reproduction.

Long-term dolphin declines in anthropogenic disturbance "Ground Zero"

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After direct harvesting, noise pollution is the anthropogenic activity with the most negative impacts on coastal cetaceans like bottlenose dolphins (*Tursiops sp.)*. A 14-yr BACI study of a 5-year, geographically-localized bridge construction project over a vital dolphin corridor connecting the ICW and Gulf of Mexico in western Florida provided a case study of bottlenose dolphin occurrence patterns concurrent with chronic habitat disruption, primarily noise pollution. This report compares dolphin occurrence in the area directly impacted by construction activities or "ground zero" before, during, and after construction. Dolphins were documented on small boat surveys 2-4 times/wk, N = 1327 surveys, 2005-2017. Occurrence was examined as total numbers of dolphins and presence/absence. For total numbers, ANCOVA revealed a significant steady decline after controlling for time, temperature, and total dolphins in the entire study area. After construction, dolphin numbers dropped below the grand mean and stayed uniformly low for 7 years without evidence of recovery. In contrast, for absence/presence, odds stayed at 'even odds' and logistic regression showed that relationships between social/environmental parameters and sighting odds also remained consistent. Findings were that habitual use of this vital dolphin corridor did not change despite steadily fewer dolphins using it in the 7 years post-construction. Conclusions are that changes in coastal cetacean behavior concurrent with coastal construction may last long after anthropogenic disruption has ended without signs of obvious recovery but could be easily missed without concerted scientific documentation. Marine mammals need urgent conservation measures and this study provides important management information about potential longer-term effects.

Satellite imagery and citizen science reveal the ecology of abundance and distribution of Crabeater seals in the Weddell Sea

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Crabeater seals (*Lobodon carcinophaga*) are labelled as the most abundant seal species in the world. Native to Antarctica, with a circumpolar distribution, their population estimates range from 2-75 million (current best estimate = 8 million). Based on observations from shipboard and aerial surveys, crabeater seals prefer to live and breed on loose pack-ice – however, this potentially biases current knowledge about crabeater seal ecology given ship surveys are limited by sea ice conditions. Thus, much of the inaccessible and highly concentrated pack ice has been little explored for seal abundance. Here, we combine satellite images and citizen science to determine firstly the population size and density of crabeater seals in the Weddell Sea and secondly, to

understand the abiotic factors that influence crabeater seal distribution. High-resolution satellite images covering an area of ~18,000 km2 in the Weddell Sea (October 2018) were hosted on the crowd-sourcing platform Tomnod (DigitalGlobe). Citizen scientists marked maps where seals were present or absent, and experienced observers manually counted seals from the reduced number of images. About 2% of maps were open water, 60% were covered by extensive sea ice, and 17% of maps contained small or mixed ice floes. Crabeater seals were present on 71% of the mixed size ice floes at a density of 0.065 seals/km2. Abiotic variables, such as ice concentration and floe size were used in habitat suitability models to understand seal abundance and distribution. Crabeater seals preferred small ice floes within the Marginal Ice Zone; the deep Weddell Sea with extensive year-round ice were almost devoid of seals. These new and comprehensive insights into the distribution and abundance of crabeater seals will provide a baseline to which future population estimates can be compared and allow us to predict how crabeater seals will respond changes in sea-ice composition due to climate change.

Translating science into policy: How the presence (or absence) of evidence can be used to develop conservation measures for endangered whale populations.

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Strong conservation measures for endangered species should, according to the U.S. Endangered Species Act, be based in the best available science. With the considerable challenges in collecting data on highly mobile and widely distributed marine mammal species, however, the best science is not always available. When developing management initiatives to protect highly endangered marine mammal populations, such as Southern Resident orcas and North Atlantic right whales, an absence of evidence is sometimes misinterpreted by those influencing policy decisions as evidence of absence. Science on marine mammals often raises additional questions, reminding us more about what we don't know than confirming what we do know. Translating this information into concrete policies presents considerable challenges from the conservation perspective. How do we ensure strong measures are developed and enacted to protect endangered orcas and right whales when significant data gaps exist for these populations, and how can researchers and conservationists help policymakers fill in those gaps? For example, scat collection from Southern Resident orcas can provide information on nutritional status and toxicant loads for individual orcas, but is usually only collected when the orcas are in their summer foraging habitat. This leaves an absence of information on the condition of the orcas' winter and spring habitat and prey resources; however, the nutritional status of individuals as they return to their summer range can be used as a proxy for the health of their winter and spring environment, and can help guide the development of additional protective measures. Researchers and conservationists can work together to use the "best available science" to bridge the data gaps and translate science into policy for the sake of endangered species recovery.

Behavioral and environmental context of Antarctic minke whale vocalizations

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Acoustic signaling is the predominant form of communication between cetaceans, and understanding the behavioral state of calling individuals can provide insights into the specific function of these vocalizations. For cryptic species, this information can be especially useful when evaluating passive monitoring data sets to estimate species presence, density, and behavior. The most numerous baleen whale in the Southern Ocean is the Antarctic minke whale, however little is known about their acoustic behavior. We used motion-sensing tags with concurrent video and acoustic recording abilities deployed on 29 Antarctic minke whales around the Western Antarctic Peninsula. We used the data collected from these tags to characterize the whales' vocal repertoire and assess the associated behavior of both tagged individuals and others present in animal-borne videos. Acoustic data was manually audited for calls when concurrent video data was also available. Vocalizations were sorted into distinct call types based on several known acoustic parameters including 90% call duration, frequency bandwidth, and frequency quartiles. Call types were then

compared to concurrent video data to determine the behavioral state and environmental conditions (e.g., sea ice cover) of the individuals during periods of vocal activity. Our results demonstrate that Antarctic minke whales produce several distinct sound types ranging in frequency from 180-560 Hz, and consist of pulse trains, down-sweeps, growls, and other sound types not previously described in the literature. Vocalizations are produced during distinct behavioral states including foraging, travel, socializing, resting and are emitted both in solitary and in groups of up to five animals. Additionally, vocalizations were emitted in both open water and heavy sea ice conditions. Our results represent a significant advancement in our understanding of the life history and behavior of Antarctic minke whales and improve our capacity to acoustically monitor this species in an ever-changing Antarctic region.

Effects of body size, food type, and ontogeny on chewing cycle duration in West Indian manatees (Trichechus manatus).

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Mastication is the cyclical pattern of mandibular movements in mammals and can be measured as a rate (chews/sec) or the inverse (chewing cycle duration; CCD). Mastication rate is a key variable in models of feeding ecology. A positive, interspecific relationship exists within mammals between CCD and body mass; however, intraspecific patterns have not been as clear. This study investigates the effects of body size, food type, and ontogeny on CCD in West Indian manatees (*Trichechus manatus*). We recorded 18 captive manatees of varying body lengths consuming two food types. Additionally, nine of these manatees were recorded on two separate occasions, six years apart, allowing us to examine ontogeny. Curved body length was measured along the dorsal surface. CCD was extracted from the recordings using Raven Pro 1.5. Food type ($r = 0.78$, $p = 6.8x10\text{-}5$, $n = 17$) and body length ($r = 0.53$, $p = 0.033$, 95%CI 0.14-1.00, $n = 17$) significantly affected CCD. Individual variation remained consistent even while CCD changed during growth. Both CCD and body length increased over time; however, our small sample lack the statistical power needed to show a significant correlation between ΔCCD and Δbody length ($r = 0.44$, $p = 0.24$, 95%CI -0.198-1.00, $n = 9$). Considering all three contributing factors influencing CCD, we conclude from our study that it might be difficult to accurately estimate body length from mastication sounds due to individual variation (independent of body size and food type). It may possible to determine relative body size if food type is controlled for. In addition, while mean CCD (543 ms) varied between manatees by as much as 144ms, each individual chewed at a consistent rate (mean SD = 41), which may allow individuals to be distinguished from each other in the wild.

Distribution and movements of sei whales (Balaenoptera borealis) on coastal feeding grounds in the Falkland Islands (Malvinas).

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Southern Hemisphere sei whales (*Balaenoptera borealis*) were heavily impacted by 20th century whaling operations. Knowledge of their present-day distribution, abundance and ecology is poor. To address that data gap, boat-based surveys targeting sei whales were carried out around the Falkland Islands (Islas Malvinas) during the austral summer and autumn between 2017 and 2019, focussed on three coastal (≤30 km distance from shore, and ≤100 m depth) study sites. Standardised visual methods, photo-identification, faecal sampling and biopsy sampling were implemented. Sei whales were the most frequently-sighted cetacean species, and were distributed throughout the coastal waters surveyed, including nearshore habitat (to <200 m from the shoreline), inside semi-enclosed inlets and channels, and over shallow water depths (500 m grid cell values: 2 to 107 m depth). Approximately 300 sei whales were photo-identified from natural markings including scars and dorsal fin marks. Photo-identification analysis revealed movements of individuals between the east and west coasts of the Falklands, and recaptures in different years. Observational and faecal sampling data indicated that sei whales use Falkland waters for feeding, with over 100 faecal events observed over the three seasons. Visual analysis via microscopy of 19 faecal samples from 2017 revealed the body parts of the crustacean squat lobster (*Munida gregaria*) in all samples. Surface feeding was observed on *M. gregaria* during 2017 and on the amphipod *Themisto gaudichaudii* during 2019. The presence of several cow-calf pairs during 2019 suggests that Falkland waters could be used by lactating females following calving the previous winter/spring. These

combined data indicate that the Falkland Islands represent a significant coastal foraging ground for globally endangered sei whales. Further understanding of their distribution, population dynamics and ecology is integral to maximising effective conservation management of the species in the Falkland Islands, and throughout the wider South Atlantic region.

Defining shelf break soundscapes of southern Georges Bank, western North Atlantic Ocean.

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Within a soundscape, anthropogenic sound occurs in and often dominates frequency ranges used by certain species, leading to overlap of signals and potential communication masking. To evaluate the extent of this acoustic overlap, it is helpful to understand how species utilize different acoustic niches across time. This study's primary goal was to assess the co-occurrence of cetacean species and anthropogenic activities, and to present simple and accessible visualizations of the temporal and spectral overlap representing site-specific acoustic niches. Acoustic data were collected using archival underwater acoustic recording devices, known as High-frequency Acoustic Recording Packages (HARPs). Programmed to sample continuously at 200 kHz, HARPs were deployed near three deep-water canyons (Heezen, Oceanographer, and Nantucket) along the continental shelf break of Georges Bank from April 2015 to March 2016. Recording durations were 271, 288, and 145 days, respectively. Daily presence data were compiled for six baleen whale species (North Atlantic right, fin, blue, sei, humpback, and minke), five odontocete species and/or groups combined according to the primary frequency ranges and ease of identification of their sounds (delphinid spp, sperm whales, Kogia spp, Sowerby's and Cuviers'/True's/Gervais' beaked whales), and four anthropogenic sound sources (airguns, vessel noise, echosounders, and explosions). At each site, both cetacean and anthropogenic sources were found to be major contributors to the soundscape. Individual cetacean species or groups were present from 0.37% to 100% of days across sites, with dolphins, sperm whales, and fin whales detected most consistently. Airgun noise was the most frequently detected anthropogenic signal, ranging from 50-91% of days across all sites, followed by vessel noise (21-59% of days), and echosounders (4-20% of days), with one explosion detected at Oceanographer Canyon. This approach allows for broad comparison of species and anthropogenic activity composition, providing an understanding of variability in acoustic overlap and potential masking between sites.

Bottlenose dolphins and red tide harmful algal blooms: Are patterns of dolphin responses emerging from repeated events?

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Bottlenose dolphins exhibit strong site fidelity to many Gulf of Mexico bays that experience red tide (*Karenia brevis*) harmful algal blooms. Blooms vary in spatial coverage, duration, and severity, but can cause direct dolphin mortality from brevetoxins, as well as lagged ecological impacts from prey fish mortalities. A severe red tide along the central west coast of Florida in 2005-06 was

associated with temporary changes in dolphin habitat use, declines in body condition, and increased adverse human interactions, including deaths of 2% of resident Sarasota Bay dolphins from recreational fishing gear ingestion. Fish surveys documented a decline of 75% for the dolphins' primary prey fish, suggesting a reason for increased interest in anglers' bait and catch. Fish numbers did not return to pre-bloom levels for two years, and dolphins continued to exhibit elevated levels of human interactions. Were the changes observed in association with the 2005-06 severe red tide a model for what may happen as blooms are expected to increase in severity and frequency with climate change, and if so, what can be done to reduce human impacts to dolphins? A severe red tide in 2018-19 is providing an opportunity to look for patterns of changes. To date, we have documented the loss of 88% of dolphin primary prey fish, and initial findings indicate changes in dolphin behavior, trophic level at which they are feeding, body condition, and occurrence of skin lesions. Our passive acoustic monitoring network is documenting dramatic ecosystem changes. Within a 3-week period, we disentangled two 2-yr-old calves from recreational fishing line in areas affected by the bloom. Continuing research is focused on determining whether we can predict circumstances under which increased adverse human interactions might be expected to occur, allowing us to proactively target outreach efforts to try to reduce anthropogenic impacts.

Effects of distance and received level on sonar-induced behavioural disturbance in two deep-diving cetaceans.

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Quantitative environmental impact assessments for naval activities typically use acoustic received levels to predict behavioural disturbance in marine mammals. However, recent observations in areas with frequent sonar activity suggested that deep-diving cetaceans may learn to associate exposures from distant sonar sources with lower perceived risk. We conducted at-sea experiments with northern bottlenose whales (n=12 individuals) and sperm whales (n=16 individuals) to investigate the roles of received level and source distance on their behavioural responses to naval sonar. Subjects were tagged with high-resolution archival DTAGs or medium-resolution satellite tags and subsequently exposed to pulsed sonar in the 1-4 kHz frequency band. Our novel experimental design included different sonar systems with different maximum source levels including a full-scale operational sonar source, and dose escalation with a ramp-up of source level, to separate received level from source distance as the main driver of response. Experiments with northern bottlenose whales were conducted in the relatively pristine underwater acoustic environment of Jan Mayen. Sperm whales were experimentally exposed in waters off mainland Norway, in an area with more frequent naval sonar activity. Northern bottlenose whales exhibited relatively severe behavioural responses with avoidance threshold sound pressure levels ranging from 117-126 dB re 1 µPa, similar to other tagged beaked whales. The onset and intensity of their responses did not appear to be influenced by source distance (to the 28 km tested). In contrast, sperm whales exhibited less severe behavioural responses which abated more quickly and generally were initiated at higher received levels and shorter distances to the source. Combined, these experiments highlight the importance of exposure factors such as received level, as well as of contextual factors such as species and pristineness of the habitat. Our results enable more accurate predictions of behavioural disturbance in deep-diving cetaceans and should help navies to reduce the environmental effects

A computer model for studying fishing gear modifications in virtual reality to prevent large whale entanglements

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Whale entanglements occur worldwide in all types of fishing line and netting, and involve all species of baleanopterids. For some species and

populations, such as the critically endangered North Atlantic right whale (*Eubalaena glacialis*), it is the most immediate threat to its persistence and recovery. Evaluating fishing gear modifications for threatened species is challenging given that low population abundance makes entanglement events relatively rare, and therefore field experiments to compare the effects of gear alterations with control (typical) gear cannot generate sufficient statistical power. The fishing industry and regulators therefore rely on intuition or limited scientific evidence when implementing gear changes. To provide a more evidence-based approach for making decisions regarding reducing whale entanglement incidence and severity, we developed a computer model that graphically simulates encounters between a North Atlantic right whale and pot gear. The whale is an anatomically accurate model capable of articulating in ways similar to an actual right whale, and the fishing gear was constructed using actual physical properties of ropes. Among the initial evaluations of this model, we examined rope with a breaking strength of

Biomechanics of the rorqual temporomandibular joint.

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Rapid engulfment and expulsion of massive volumes of water (15-80+ m^3) during rorqual (balaenopterid whale) lunge feeding—dubbed the greatest biomechanical action in the animal kingdom—depends on a strong yet flexible jaw joint that can withstand intense forces. We investigated the mobility, strength, and elasticity of the temporomandibular joint (TMJ) in adult, juvenile, and fetal minke (*Balaenoptera acutorostrata* and *B. bonaerensis*) and fin (*B. physalus*) whales. Using a strain gauge potentiometer attached to jaws of deceased specimens, we recorded rotational angles in three dimensions (jaw abduction, longitudinal rotation, and horizontal displacement around condylar and symphyseal axes) and found that at full gape (>90 degrees), the posterior (condylar) end of the mandible is medially rotated ~30 degrees, laterally displaced, and slightly elevated and retracted. However, during an early phase of jaw abduction the mandible rotates laterally ~7 degrees and the condyle is slightly medially displaced, suggesting an unstable intermediate position. These changes may aid in locking/unlocking and strengthening gape during lunge feeding. Joint angles were verified via goniometer and confirmed by CT scans showing bony and soft tissue movement. The non-synovial rorqual TMJ has a large fibrocartilage pad with scattered collagen and elastin fibers. Laboratory and field experiments revealed multidimensional stress/strain curves as the TMJ pad is loaded and unloaded, with slightly greater elasticity in the mediolateral plane (with deformation of about 200% under tensile stress of 35 MPa and deformation of nearly 100% under compressive loading of almost 25 MPa) relative to the anteroposterior plane, and with the least "stretchiness" (in compression and tension) in the dorsoventral plane. These give the rorqual TMJ a tremendous capacity to dampen acceleration and absorb shock during engulfment, and to aid in gape closure during filtration by elastic recoil with conversion of stored potential energy into kinetic energy.

3-D modeling to assess habitat impacts from underwater noise

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The soundscape of the marine environment includes biologically relevant information for marine species and affects their ability to detect predators and prey, locate conspecifics, and orient themselves within their environment. While most regulations relevant to sound in the underwater environment focus on the acute impacts of acoustic and explosive noise on individual marine species, the quality of the acoustic environment within the habitat has recently become an international focus for assessing impacts to marine species. In the United States (U.S.), the description of critical habitat for the endangered Main Hawaiian Islands insular false killer whale (*Pseudorca crassidens*) distinct population segment includes sound levels that would not significantly impair false killer whales' use or occupancy of their habitat. The European Union (E.U.) has established a goal of ensuring underwater noise does not adversely affect the environment. However, both in the U.S. and the E.U., there are no standard methods to estimate the impact of future actions. The U.S. Navy has used the Navy Acoustic Effects Model (NAEMO) to quantify impacts of navy sonar and explosives on

marine species. Here, we demonstrate the viability of using this model to analyze the spatial and temporal contribution of Navy activities on habitat soundscapes. Habitat modeling will identify the proportion of habitat that is impacted at different levels and types of anthropogenic activity. Proportions of habitat will be quantified where individual animals could incur injury, behavioral changes, and masking. Habitat modeling allows for a broad analysis and anticipates the need to analyze with a more comprehensive approach in future analyses.

A novel pulmonary vasculitis in grey seals (Halichoerus grypus) associated with Otostrongylus circumlitus infection.

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Lungworm infection in seals is an important cause of morbidity and mortality inducing bronchopneumonia affecting population dynamics in some areas of the world. We present a series of cases of lungworm infection in grey seals associated with novel, significant and highly unusual pulmonary vascular changes.180 grey seals either stranded, in rehabilitation or long-term captivity from the UK were subject to post-mortem examination between 2012 and 2018. Lung was collected from 47 individuals for histopathological examination. Nematode morphology within sections was evaluated histologically. PCR on FFPE material was attempted for parasite identification on selected sections using lungworm specific primers.14/47 (30%) of grey seals showed evidence of segmental granulomatous and eosinophilic vasculitis with intramural Splendore-Hoeppli reaction in medium to large pulmonary arteries. Intra-vascular nematodes suggestive of *O. circumlitus* were seen in 2 cases. PCR on FFPE material was unable to detect a signal on selected tissue sections. 9 animals had concurrent bronchopneumonia and 4 had intra-alveolar/bronchiolar *Parafilaroides species*. 13/14 animals with vasculitis lesions were weaned pups with only 1 adult affected. Previous pathological descriptions of lungworm infection in grey seals have dealt mainly with the bronchopneumonia. This case series has identified previously unrecorded vascular changes characterised by the deposition of intra-mural Splendore-Hoeppli reaction. Such change would impact on vascular integrity increasing the likelihood of vascular rupture with pulmonary haemorrhage and increased risk of intravascular coagulation. An aberrant host-parasite relationship with the persistence of antigenic material following close contact with or migration through the blood vessel wall is suspected.

Oxytocin quantification in serum using liquid chromatography/mass spectrometry (LC/MS) and enzyme immunoassay (EIA) in bottlenose dolphins (Tursiops truncatus)

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Oxytocin is a neuropeptide synthesized by the hypothalamus and secreted by the posterior pituitary gland which has been shown to a play a role during the *periparturient* period, lactation, and maternal and offspring bonding in terrestrial mammals but its role in cetaceans is not known. An accurate and reliable method for quantitating circulating concentrations of oxytocin will provide a tool to evaluate the role and diagnostic and prognostic value of oxytocin during various reproductive states in cetaceans. A liquid chromatography-mass spectrometry (LC-MS) method was adapted for measuring oxytocin in dolphin serum. A calibration curve was established for 0.10-100 ng of oxytocin, correlating to a serum concentration limit of detection at 125 pg/mL. However, oxytocin was not detected in pooled serum from adult bottlenose dolphins (0.5 mL sample volume). Additional oxytocin extraction and concentration steps on larger serum volumes will be needed to detect and quantify oxytocin by LC-MS. In parallel, an oxytocin enzyme immunoassay (EIA) kit (Arbor Assay) was adapted for use with dolphins using a pool of serum from adult animals. A minimum of 3.2 mL of serum was used for extraction to yield a x10 concentrated sample. Parallelism relative to the oxytocin standard curve was indicated using dilutions (x10, x5, x2) of the extract. Recovery of 101% was indicated after low, medium, and high oxytocin standards were added to the extract. Sensitivity of the assay was 19 pg/mL. Results indicated a need for sample extraction to concentrate oxytocin for EIA, which is in accordance with that previously reported in cattle, horses, pigs, goats and sheep. While these initial

results provided successful validation of the LC-MS and EIA performance and quantitation of oxytocin in a pool of dolphin serum, the biological relevance in serum samples from *periparturient*, lactating, and non-lactating female and male bottlenose dolphins needs to be assessed.

Palaeogenomic and stable isotope data reveal the responses of bowhead whales to climatic perturbations during the Late Pleistocene and Holocene.

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The bowhead whale (Balaena mysticetus) is the only baleen whale endemic to Arctic waters. It plays a central part in the Arctic ecosystem and its evolutionary history is closely tied to the environmental dynamics of the region. The bowhead whale has a uniquely large fossil record in the central Canadian Arctic and Svalbard spanning the last approximately 50,000 years. This sample set enables a comparative study of the environmental changes in two independent locations and the resultant evolutionary responses of bowhead whales during the Late Pleistocene and Holocene. Using carbon and nitrogen stable isotopes recovered from this unique assemblage, we address how the bowhead whale diet changed in real time, giving insights into shifts in primary producers and by proxy, shifts in the Arctic palaeoclimate. Furthermore, using high throughput next generation sequencing of ancient DNA (aDNA), resulting in both mitochondrial and nuclear genomes, we uncover the genetic responses of bowhead whales to the climatic changes throughout the Late Pleistocene and Holocene. The genetic data allows us to directly investigate how changes in the environment influenced population structure and uncover patterns of genetic isolation and gene flow through time. Our findings provide an in-depth understanding into the genetic responses of bowhead whales to past climate change and can aid in the formation of informed inferences about the resilience of bowhead whales to rapid current global climate change.

Western Hudson Bay estuary use for calf rearing

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Social and spatial segregation of sexes is common amongst vertebrates that live in groups. Whale species such as the North Atlantic right whale (*Eubalaena glacialis*), North Pacific gray whale (*Eschrichtius robustus*) and bowhead whale (*Balaena mysticetus*) are known to have nursery areas where females feed and take care of their young. Although segregation of older adult males from immature males and females is known to occur in some beluga whale (*Delphinapterus leucas*) populations, it is unclear if adults accompanied by calves segregate for periods of time during the year in the eastern Canadian Arctic, where the largest summering population is found. A long held hypothesis has been that western Hudson Bay estuaries are critical for calf rearing by offering protection from predators, warmer waters for thermal advantage, and feeding opportunities, but no study has looked closely at the distribution and habitat use of mothers with calves. Using imagery from a photographic survey conducted in August 2015, we evaluated whether adults accompanied by calves use estuaries and near shore habitat more than other age classes in western Hudson Bay in the summer. Photographs were taken using two Canon cameras (25 mm and 50 mm lenses) mounted on a twin otter flying at 2,000 feet over the Churchill and Seal River estuaries (complete photographic coverage) and offshore areas (transect coverage). Belugas were identified and classified by age manually using an identification decision tree that considers length and color and GPS coordinates were plotted in ArcGIS. Distribution by age class was examined in relation to distance to coastal habitat and bathymetry (predation theory), water temperature (thermal advantage), and chlorophyll-a (as a proxy for feeding opportunities). Further understanding of spatial patterns of belugas habitat use in western Hudson Bay is necessary to provide conservation and management advice.

Did grey seals reproduce in the German Baltic Sea before their extinction in 1920? Historical records provide answers to a controversial question determining future management decisions.

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After a strong population recovery, in 2018 and 2019 the first two grey seal births were recorded in the German Baltic Sea since their return into this waters in 2005. Simultaneously, a rising number of juvenile grey seals resting on beaches and carcases of juvenile seals washing up was recorded in the last few years. The last grey seal was shot in 1920 in the German Baltic Sea. Nowadays, grey seals are present year-round and with increasing densities again, especially around the island Rügen. The return of grey seals was a great success of effective, long-term, international nature conservation measurements. In many cases, the return of a top predator causes controversial and highly emotional conflicts between different interest groups. Therefore, the question if grey seals had reproduced in this region of Germany, before they got extinct, is of high importance for future management decisions. Unfortunately, historical records, partially handwritten notes, are rare. Consequently, we collected and analysed all available data about "white pups", indicating grey seal pups with lanugo fur. There are 26 evidences of grey seal pups between 1893 and 2019 for the German Baltic coast, with only one clear evidence before the extinction in 1920. Surprisingly, there are 13 evidences of grey seal pups in the time span of its presumed absence in Germany, indicating that grey seals had never entirely disappeared. In recent years, the number of pups sighted increased steeply, though most of these pups were already several weeks old, they are not deemed to be born here. The 2018 and 2019 birth records show that births occur on our coast. Therefore, the Southern Baltic Sea, including the German coast, probably was and is an reproduction area of grey seals even though there were no proofs of a historic established pupping sites in the German Baltic.

Recent occurrence of marine mammals off Angola and first report of right whales since whaling era

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Marine megafauna occurrence was recorded in deep offshore waters during an Environmental Baseline Study. The goal of this study was to characterize the habitat and biodiversity of an area of oil and gas exploration 400 km northwest of Luanda, Angola. These offshore shipboard surveys were conducted during September 2018, in water depths ranging from 2,350 m to 3,850 m. We recorded opportunistic sightings of marine mammals during daytime visual observations and conducted passive acoustic monitoring at night to record vocalizing marine mammals. A variety of species were visually recorded, including humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), common dolphins (*Delphinus* spp.), and striped dolphins (*Stenella coeruleoalba*). Most notably, southern right whales (*Eubalaena australis*) were visually confirmed in these waters. This is the first confirmed record of this species in Angolan waters since the early 1900s. In addition, a five-second bout of variable-frequency-range clicks spanning 7 kHz to 40 kHz was recorded, as well as additional click bouts potentially suggestive of sperm whale and other odontocete vocalizations.

Porpoises versus people? Mental models, conflict, and conservation pathways in the case of vaquita (Phocoena sinus) conservation.

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The steady slide of the vaquita (*Phocoena sinus*) toward extinction has been a high-profile, high-conflict conservation disaster. The main threat to this Critically Endangered species is bycatch in gillnets for shrimp (a vital livelihood for local communities) and the illegal totoaba fishery. Conservation actions, including a gillnet ban with a compensation scheme, ignited conflict between conservation and communities. Generally, such conflict has been shown to seriously impede conservation efforts, and can be driven by differing mental models or worldviews held by stakeholders; understanding these differences can elucidate drivers (and potential solutions) of conflict. We conducted semi-structured interviews of fishers, community members, government agencies, conservation groups, and researchers about their conservation values and perceptions about the process and impacts of conservation. Findings confirm substantial discrepancies, but also unexpected alignment, between mental models of conservation-affiliated stakeholders and local communities on several topics, grouped in four categories: general interactions (trust, communication, inclusion); management (priorities, scope, value of the vaquita); social impacts (type and severity); and other stakeholders (and their presumptive mental models). Among a subset of respondents, there was a disconnect between their negative assumptions of the values of the "other group" (conservation or community) and what respondents from that "other group" expressed about their own values. The situation is much more nuanced than a dichotomous "pro-porpoise versus pro-people" conflict, though it is often framed as such. Sharing mental models might indicate unexpected

commonalities while promoting empathy for conflicting viewpoints, which is essential for conflict transformation. For the vaquita, it is almost certainly too late to integrate understanding of mental models into conservation. However, other important local management issues remain that will require better conservation-community relationships. This evaluation also holds important insights for the global issue of bycatch; learning from this conservation failure is one way to salvage something from the vaquita's plight.

An evaluation of Mahalanobis distance as a method to detect behavioural response in marine mammals from tag data

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Behavioural response studies aim to identify and characterize how animals respond to disturbances such as naval sonar or noise from marine renewable development. Many studies use Mahalanobis distance to collapse multiple data streams, recorded from animal movement tags, into one metric that represents how behaviour changes over time; however, there is little information on how well Mahalanobis distance can detect different types of behaviour change or how different implementations of the method affect performance.

Here, simulations were developed to evaluate the Mahalanobis distance approach with different species, tags, and method implementations. From this, we provide recommendations on how best to use this method in future analyses.

The simulations considered two focal species: Cuvier's beaked whales (*Ziphius cavirostris*) and harbour seals (*Phoca vitulina*). We simulated tag time-series data that represents both baseline behaviour and responsive behaviour. Real tag data were used to calibrate a simulator of both high-resolution multi-sensor tag data (pitch, roll, heading) and low-resolution tag data (e.g. satellite tags); responses were simulated based on those reported in the literature. For the multi-sensor tags, data streams were simulated for each dive by categorising dives into types (e.g. shallow, foraging) and simulating data for each dive phase separately as a multivariate autoregressive process, capturing the dependence between data streams. For the low-resolution tags, locations were simulated as a discrete-time multistate correlated random walk where movement could be biased away from centres of disturbance. For both tag types, several Mahalanobis distance methods, each differing by how behaviour change is computed, were applied. From this, the performance of each implementation was compared across species, tag type, and differing responses.

Chemical fingerprints suggest direct familiarisation rather than phenotype matching during olfactory recognition in Australian sea lions (Neophoca cinerea)

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Olfaction is one of the most commonly used senses for communication among animals and is of particular importance to mother-offspring recognition in mammals. The use of smell in offspring recognition has been well studied, however, we often lack information about the underlying mechanistic basis for olfactory recognition. Using gas chromatography-mass spectrometry (GC-MS), we examine chemical profiles of two different colonies of Australian sea lions (*Neophoca cinerea*) and assess the similarity of chemical fingerprints in mother-pup pairs. This analysis allows us to examine whether a chemical base for phenotype matching exists in this species. Our results showed no GC-detectible mother-offspring similarity in the overall chemical fingerprints, suggesting that direct familiarization is a more likely mechanism used by Australian sea lion mothers for recognition of their young. Our analysis also demonstrates that colony differences are encoded within chemical fingerprints and appear to be highly influenced by environmental compounds. The study improves our understanding of how Australian sea lion females use odours for selective offspring recognition and the potential importance of environmentally acquired chemical

compounds in the overall odour bouquet used in mother-pup interactions.

Trophic connections between sperm whales and their prey in the Gulf of Alaska.

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Understanding top predator diets and their role in food webs is important to managing fisheries and mammals from an ecosystem perspective. Sperm whales, a top predator, overlap and interact with economically important groundfish fisheries offshore in the Gulf of Alaska. Stable isotope analysis (SIA) provides a viable way to estimate trophic position and food web connections as a proxy for diet. In particular, SIA has been used increasingly in dietary mixing models to estimate contribution of prey to predators' diets. This study aims to use SIA to better understand the trophic variability of sperm whales and their potential prey, and to estimate the importance of potential prey items to their diets. We analyzed skin samples from 33 sperm whales and 262 tissue samples from seven potential prey species (five groundfish and two squid). Samples were analyzed for stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios, and diet composition was estimated using Bayesian isotopic mixing models. Two groundfish species, sablefish and spiny dogfish, were combined due to their overlapping isotopic signatures (sablefish/dogfish group). Mixing model results suggest that the sablefish/dogfish group, skates, and rockfish make up the largest proportion of sperm whale diets (35%, 28%, 12% respectively) in this region, though estimates have high uncertainty. The top prey items of whales that interact more frequently with fishing vessels consisted of skates and the sablefish/dogfish group (49% and 24% respectively). This is the first known study to provide a complete isotopic analysis of these adult groundfish and squid species, as well as of adult male sperm whales in this region. Additionally, it is the first study to attempt to assign proportional contributions of prey species to sperm whale diets in the Gulf of Alaska, thereby providing information to commercial fishermen and fisheries managers to better understand trophic connections of important commercial species.

Of shells and sponges - contrasting social transmission pathways of foraging behaviour in dolphins using social network analysis

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Behavioural differences among groups can arise from differing ecological conditions, genetic predispositions or social transmission of different behavioural innovations. Previously, social learning has typically been inferred as responsible for the spread of behaviour by the exclusion of ecological and genetic factors. This 'method of exclusion' was used to infer that 'sponging', a foraging behaviour involving tool use in the bottlenose dolphin (*Tursiops aduncus*) population in Shark Bay, Western Australia, was socially transmitted. However, previous studies were limited in that they never fully accounted for alternative factors, and that social learning, ecology and genetics are not necessarily mutually exclusive drivers of behavioural variation. Here, we assessed the relative importance of these three potential drivers on the spread of two foraging behaviours, sponging and shelling, in western Shark Bay between 2007 and 2018. Using multi-network 'Network-Based Diffusion Analysis' (NBDA), we found compelling support for sponging being socially transmitted between mother and offspring ($\Sigma w_i = 0.837$), corroborating previous results. Mother-offspring similarities in foraging behaviour are common, as close association during prolonged periods of dependency favour conditions for vertical learning. In stark contrast, we found that shelling spreads among associated individuals ($\Sigma w_i = 0.771$), quantitatively establishing horizontal social transmission of a foraging tactic in toothed whales for the first time while also accounting for genetics and ecology. The opportunistic nature of shelling and extensive social tolerance among adults may have allowed for social transmission outside of the mother-offspring bond. Overall, our research suggests multiple pathways of transmission of foraging behaviour in dolphins, and illustrates the utility of social network analysis in elucidating the explanatory mechanisms behind the spread of behaviour in wild animal populations.

First documentation of coordinated bottom-feeding by humpback whales

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Humpback whales coordinating prey capture efforts in surface bubble-feeding groups are well documented. Here, we provide the first documentation of humpbacks coordinating feeding behavior to capture prey on the seabed. Observations were made using multi-sensor/video-recording CATS-CAM tags placed on humpback whales feeding on sand lance (*Ammodytes dubius*) in the southern Gulf of Maine, USA. Visually documenting bottom-feeding behavior is challenging, since it characteristically occurs at night or in waters too deep to provide light for video-recording. From 2016-2018, we collected video data showing this behavior within and across years (1 from 2016, 3 from 2017, and 7 from 2018). Preliminary analyses describe 30 bottom feeding events occurring over 75 minutes from a juvenile female humpback (2018) in a three-member feeding group targeting sand lance schooled along the seabed at a depth of ~40m. In all events, animals were at or in contact with the bottom, often creating visible sand plumes. Individuals were oriented in a "star" formation, with rostrums pointed to a central location among the whales. Separation ranged from a few meters to rostrums almost touching. In each event, individual whales, identified by unique body markings, maintained the same feeding position relative to each other, usually 10 and 2 o'clock to the tagged whale. Animals opened their mouth within four (±3) seconds of each other. When gaped, animals were rolled ~90°, forming a "corral" with their open mouths, with sand lance visible in, and escaping from, the corral. When multiple feeding events occurred within a single dive, the animals repeated their original positions within the feeding group in as few as 23 seconds from the proceeding event. This behavior adds to our understanding of humpback complexity and makes them particularly vulnerable to bottom-set fishing gears.

Three concurrent Western Atlantic large whale unusual mortality events

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Since 2016, three Unusual Mortality Events (UME) have been declared by the U.S. National Marine Fisheries Service for baleen whales in the Western Atlantic Ocean along the coast of the Canada and the United States. These three concurrent events involve humpback whales (*Megaptera novaeangliae*; 2016-present), North Atlantic right whales (*Eubalaena glacialis*, 2017-2018), and minke whales (*Balaenoptera acutorostrata*, 2017-present). To date, over 170 whales have stranded live or dead as part of these UMEs: 93 humpback, 20 North Atlantic right and 59 minke whales. This elevated stranding rate may have consequences at the population or stock level, particularly for North Atlantic right whales, as the most recent minimum population estimate is only 455 whales. Although the reasons for stranding have differed between the three species, all three have had evidence of human interaction in a sub-set of whales, including vessel strikes in humpback whales, rope entanglements and vessel strikes in North Atlantic right whales, and entanglements in minke whales. Additionally, a sub-set of minke whales has had evidence of

infectious disease, although a consistent primary pathogen has not been determined. The investigation is ongoing; the stranding network continues to respond and document new strandings and the investigative teams continue to explore population, ecological, anthropogenic, and other drivers that may be contributing to the increase in stranded whales. This presentation will review the current status of all three UMEs and identify commonalities and differences between the responses and investigations.

I get by with a little help from my friends: Understanding bottlenose dolphin social affiliations in response to shark-inflicted injury.

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Social living has been, in part, suggested to be a behavioral response to reduce predation risk. While many studies have assessed the effects of prey group size on predation risk, few have evaluated if or how prey group size and social dynamics change in response to direct predation events. The Sarasota Dolphin Research Program has documented long-term, multigenerational residency of common bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. Large sharks are known to inflict bite wounds on these dolphins. We assessed whether dolphins undergo shifts in their social behavior after injurious shark predation attempts. Using photographs collected during photo-ID monitoring surveys and capture-release projects, fresh shark bite wounds on resident dolphins were identified. For each dolphin with a shark bite, a dolphin of the same sex and life stage during the period in which the shark bite occurred was selected as a control animal to compare whether any potential shifts in number of affiliates were in response to the shark bite. Timing of a fresh shark bite could be determined for 56 unique Sarasota Bay dolphins. A Poisson generalized linear mixed model showed there was no significant difference in group size post-shark bite. This observation could be due to the differential response among individuals as some animals increased their group size after shark-inflicted injury, while others decreased or showed no change in their group size. Although the dolphins did not change their group size in a predictable direction, they may change with whom they associate, which is being investigated through social network analyses.

Juvenile harbour porpoises in the UK are exposed to a more neurotoxic mixture of polychlorinated biphenyls than adults.

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Polychlorinated biphenyls (PCBs) are a group of 209 persistent and bio-accumulative toxic pollutants present as complex mixtures in human and animal tissues. Harbour porpoises accumulate some of the highest levels of PCBs because they are long-lived mammals that feed at a high trophic level. Studies typically use the sum of a suite of individual chlorobiphenyl congeners (CBs) to investigate PCBs in wildlife. However, toxic effects and thresholds of CB congeners differ, therefore population health risks of exposure may be under or over-estimated dependent on the congener profiles present. In this study, we found congener profiles varied with age, sex and location, particularly between adult females and juveniles. We found that adult females had the highest proportions of *octa*-chlorinated congeners whilst juveniles had the highest proportions of *tri*- and *tetra*-chlorinated congeners. This is likely to be a consequence of pollutant offloading between mothers and calves during lactation. Analysis of the individual congener toxicities found that juveniles were exposed to a more neurotoxic CB mixture at a time when they were most vulnerable to its effects. These findings are an important contribution towards our understanding of variation in congener profiles and the potential effects and threats of PCB exposure in cetaceans.

Killer whale predation on bowhead whales in the Pacific Arctic – on the rise?

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Review of imagery and sighting data on bowhead whale (*Balaena mysticetus*) carcasses from a decade of aerial surveys in the eastern Chukchi and western Beaufort seas has provided new and robust evidence for killer whale (*Orcinus orca*) predation on bowhead whales of the Bering-Chukchi-Beaufort (BCB) stock. The Aerial Surveys of Arctic Marine Mammals project provides information on distribution, behavior, and relative density of marine mammals, including BCB bowhead whales and their only natural predator, killer whales. These surveys cover large areas of bowhead whale summer and early autumn habitat, and offer a long time series of consistent information on floating and beach-cast bowhead whale carcasses detected during line-transect surveys. A total of 33 bowhead whale carcasses were documented in July–October, from 2009 to 2018. Carcasses were distributed across the study area from 141.6°W to 168.1°W and 68.9°N to 72.0°N. Twenty-five carcasses (76%) were found floating and eight (24%) were beach-cast. Highest number of carcasses were observed in 2015 (10/33), followed by 2013 and 2018 (6/33 each year), and 2016 (5/33). Imagery review provided insight into the probable cause of death for 21 (63.6%) of the carcasses. Seventeen bowhead whale carcasses having injuries consistent with killer whale predation were photo-documented: four carcasses per year in 2016 and 2018, three carcasses in 2013 (including one calf/yearling), two carcasses per year in 2012 and 2015 (including one calf/yearling), and one carcass per year in 2010 and 2017 (a calf/yearling). Four carcasses, two in 2015 and one each in 2013 and 2018, were likely whales struck and lost during aboriginal subsistence hunting. Continued monitoring and documentation of BCB bowhead whale mortality, including killer whale predation is needed for assessing the status of the BCB bowhead whale stock and the ecological impacts of a changing Arctic.

The scale of the whale: Using video-recording tags to determine the sea ice habitat used by Antarctic minke whales (Balaenoptera bonarensis).

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Advances in biologging technology have opened doors for new sensors and tools to aid in the remote study of wildlife. These tools allow researchers access to previously unobservable behavioral states and movement patterns of marine animals. In order to relate behaviors to environmental variables, features must be evaluated at scales relevant to the individual animal or behavior. Historically, remotely-sensed environmental data (collected via satellites) lacks the spatial or temporal resolution to adequately link with individual animal behaviors or bouts. The aim of this study is to establish a new method for remotely and continuously quantifying Sea Ice Concentration (SIC) at the scale relevant to individual whales. Motion-sensing and video-recording suction cup tags were deployed on 30 Antarctic minke whales (*Balaenoptera Bonaerensis*) in February and March of 2018 and 2019 around the Antarctic Peninsula. For each surfacing, observable surface area to be evaluated (m^2) is calculated at a constant depth as a function of tag pitch and camera angle of view. Sea Ice Concentration (SIC) was classified into one of six bins (0%, 1-20%, 21-40%, 41-60%, 61-80%, 81-100%) for the initial and final surfacing between dives. SIC was evaluated by two independent observers, and a third adjudicated disagreements, and a median of three values was used. Initial results from 6 tags show that Antarctic Minke whales spend 52% of their time in open water, and only 15% of their time in water with SIC greater than 20%. Over time, we find significant variation and switching between SIC concentrations between dives, indicating an extremely dynamic environment. Combined with information on underwater behavior, our ability to quantify SIC continuously at the scale of the animal will allow a more robust and accurate means to link animal behavior to these dynamic environmental variables,

something that is currently not possible from traditional remote sensing methods.

80 Years of chemical exposure profiles reconstructed through baleen whale earplugs

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Organic contaminants have been a concern for cetaceans due to their adverse health effects and were initially measured in marine mammals in 1966. Cetaceans often serve as sentinels of the marine ecosystem, however, limitations in historical approaches often limit our understanding. Recently, scientific discovery has found that baleen whale earplugs have the ability to record and archive lifetime chemical exposure profiles and trends. Earplugs represent a unique opportunity to examine the spatial and temporal trends in our marine ecosystem. Baleen whale earplugs were collected from six whales (1 blue whale and 5 fin whales), including four adults from archived collections and two calves from recent strandings. Contaminant concentrations (reported in $ng \cdot g^{-1}$) were determined in layers (n = 35) and were combined with age estimates to reconstruct lifetime contaminant exposure profiles, and lifetime bioaccumulation rates 30 years prior to the initial measurements made in the 1960s. Dichlorodiphenyltrichloroethane (DDT), its metabolites, and polychlorinated biphenyls (PCBs) were found to be the most dominant contaminants within most individuals and were detected during their early usage periods (the 1930s) indicating immediate contamination of the marine ecosystem following mass production. Bioaccumulation rates over the past 80 years were approximately 55 times higher in the Pacific as compared to the Atlantic. This significant difference indicates whales in the Pacific are more likely to be exposed to contaminants and potentially have a health risk. Profiles also indicate a difference between maternal offloading and environmental exposure profiles

Accounting for environmental factors and behaviour when correcting beluga counts from photographic and visual aerial surveys: Effects on abundance estimates.

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Accuracy of abundance estimates is essential for determining the conservation status of populations, whereas precision can reduce time for detecting significant population trends. The abundance of the Endangered, and currently declining St. Lawrence Estuary beluga population has been estimated using visual and photographic surveys, corrected for availability bias using a common correction factor developed for photographic surveys. However, not accounting for the longer detection time associated with visual surveys likely overestimated abundance in these surveys. A variety of other factors can affect availability, including turbidity, water depth, and animal behaviour. In this study, we developed a correction factor for availability bias during photographic and visual surveys using detailed dive profiles obtained from 30 beluga. We explored the benefits of including environmental factors and beluga behaviour when correcting for availability bias.

As expected, beluga availability to a passing aircraft was longer during visual than photographic surveys (0.308 vs 0.327-0.394 depending on perpendicular distance). Availability decreased significantly with increasing water turbidity; it also changed more rapidly over the first 3 to 4 m from the surface (5 to 23% per 0.5 m increment in depth), and more gradually at deeper depths (3 to 5% per 0.5 m increment in depth). Bottom depth affected availability through effects on dive duration, resulting in lesser availability when beluga were involved in area-restricted search than when in-between zones, where they were more likely to be in a travelling mode. Overall, turbidity had a larger effect on availability bias (1 to 5% per 0.5 m increment over the first 8 m) than animal behavior (-1% to 5% overall) and should be accounted for in priority. This study demonstrates

the importance of taking into account spatial heterogeneity and behaviour in correcting for availability bias.

Of whales and men: Understanding metal pollution in the Sea of Cortez through a one environmental health approach.

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The Sea of Cortez is one of the most biodiverse seas in the world, which Captain Jacques Cousteau famously described as "the world's aquarium", and is home to 32 marine mammal species. Yet, despite its isolation and pristine appearance, there are potentially significant anthropogenic inputs of pollution from agriculture and metal mining. Metals have emerged as a global ocean pollution concern including for the Sea of Cortez. Therefore, we evaluated metal pollution in whales in the Sea of Cortez during two different time periods: 1999 as part of a global voyage focused on sperm whales (*Physeter macrocephalus*) and 2016-2017 as part of an ongoing series of voyages focused on the Sea of Cortez. We measured levels of 23 essential and nonessential metals in seven different cetacean species found in the area. We found magnesium, iron, aluminum and zinc to have the highest concentrations across all species and all years. For sperm whales, metal levels generally decreased over time, though some like nickel remained at levels of concern. Iron and chromium increased with time. Because chromium is a global marine pollutant, we used One Environmental Health and cell culture-based approaches to contextualize the data. Using human and sperm whale cells, we found prolonged hexavalent chromium [Cr(VI)] exposure induced chromosome instability, spindle assembly checkpoint bypass and centrosome amplification in human cells. However, the same exposure in sperm whale cells did not induce these outcomes. Overall, the data indicate a recent change in the metal input to the Sea of Cortez that suggests a decreased health concern for the ecosystem for some metals, but increased concern for the genotoxic metals Cr and Ni, and that whale cells have evolved cellular strategies to protect against metal-induced carcinogenesis. This work was supported by NIEHS grant ES016893 (J.P.W.) and donors to the Wise Laboratory.

Baseline variation of steroid hormones in short-finned pilot whales (Globicephala macrorhynchus)

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Recent analytical advances have demonstrated that steroid hormones, which mediate behavior, reproduction, and stress, can be reliably measured in cetacean blubber. Integrating hormone analysis with photo-identification and genetics has the potential to enhance our knowledge of cetacean behavior, physiology and population dynamics. Increasingly, hormonal biomarkers are being used to measure the response of cetaceans to various types of anthropogenic disturbance, so it is important to establish baseline levels of these hormones. To characterize baseline concentrations of steroid hormones in short-finned pilot whales (*Globicephala macrorhynchus*), we adapted a liquid chromatography tandem mass spectrometry (LC-MS/MS) method for the quantitation of 11 steroid hormones in the blubber of this species. To assess the validity of this method, we conducted spike-recovery tests using blubber from stranded individuals. Accuracies for all hormones, which consisted of multiple androgens, progestogens, glucocorticoids, and a mineralocorticoid, fell between 86 and 112%, well-within accepted ranges. The biological validity of this method was confirmed through a comparison, which showed higher progesterone concentrations in known-pregnant females. To determine the effects of demography, seasonality, and sampling methods on baseline hormone profiles, we analyzed 73 biopsy samples, which were obtained in multiple seasons and additionally analyzed with PCR to determine sex. Preliminary analyses indicated distinct sex differences, with males and females exhibiting higher testosterone and progesterone concentrations

respectively. In addition to establishing baseline hormone relationships with sex and season, ongoing analyses evaluate hormone responses to sampling boat presence. This study establishes a framework for the comprehensive analysis of hormones in this species and highlights the importance of validations, relevant biomarkers, and contextual baseline references prior to conducting response studies.

Population density of the Northern sea otter (Enhydra lutris kenyoni) as an indicator of strep syndrome transmission mechanism

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The Northern sea otter (*Enhydra lutris kenyoni*) in Alaska, U.S. has recently experienced unusual mortality events due to Strep syndrome caused primarily by *Streptococcus infantarius*, *Streptococcus bovis*, and *Streptococcus phocae*. The pathogenicity and transmission method of this disease is currently unknown, making it difficult to predict. Preliminary evidence from higher-density populations that have experienced significant mortality suggest that population density may affect transmission. To test this hypothesis, we acquired stranding data from the U.S. Fish and Wildlife Service (USFWS), partitioned the population into discrete ranges and calculated the percentage of infected individuals in these areas from 2001 to 2014. Using abundance data from USFWS and the United States Geological Survey (USGS), among other sources, we calculated population density for these regions over time. We then tested the relationship between infection and population density using linear models and generalized linear mixed models. Additional variables considered were infected individuals' age, sex, and body condition, which were included to identify characteristics associated with infection. Additionally, we determined the primary physical locations for bacterial infection. Previous literature has noted a high percentage of bacteria in the intestines and we sought to further elucidate the physical characteristics of infection. Results indicate that population density does not significantly influence Strep prevalence, but that males are at greater risk for the disease. These results suggest that Strep may be transmitted in a frequency-dependent manner and influenced by behavioral disparities between the sexes. Additionally, the relative frequency at which certain tissues, such as the spleen, test positively for streptococci bacteria contradicts previous literature regarding bacterial presence in the intestines. Therefore, the survival and transport of streptococci bacteria by macrophages requires additional research, as does the proposal of infection via the intestines. Overall, these findings can be used to guide federal agencies in research prioritization and management.

The simultaneous analysis of multiple reproductive and stress hormones in small blubber samples of gray (Eschrichtius robustus) and fin whale (Balaenoptera physalus) using liquid chromatography mass spectrometry .

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The analysis of steroid hormones has been used to assess health in several species of vertebrates. In cetaceans, the simultaneous analysis of multiple steroid hormones can provide valuable reproductive and fitness data useful in the conservation and management of endangered and protected species. Minimally invasive blubber biopsy samples can be collected from healthy, free ranging animals and utilized in multiple analyses. The goal of this project was to develop a method, that used minimal tissue weight, to analyze a hormone panel to explore the endocrinology of the HPG and HPA axis of *E. robustus* and *B. physalus* as little data currently exists. Blubber biopsies were collected from free ranging *E. robustus* (n=38) in Baja California and blubber samples from stranded animals (n=14) off the coast of California. Similarly, samples were collected from free ranging *B. physalus* (n = 6) in the Gulf of California (n=6) and from stranded animals from California (n=3). Steroid hormones were extracted from blubber samples as small as 50mg using liquid-liquid extraction designed to address the high fat content of the tissue. Androstenedione, aldosterone, cortisol, cortisone, corticosterone, 17ß-

estradiol, estrone, 17α-hydroxyprogesterone, progesterone, and testosterone were analyzed via LC-MS/MS in either negative or positive ion mode. Additonally, we are going to compare the precision between polytron and Fastprep 24 homogenizers with *E. robustus* tissue along with a sensitivity analysis between 50mg and 150mg samples of *E. robustus* and *B. physalus* blubber to determine optimal homogenization technique and minimal tissue size requirements for steroid hormone analysis in these species. The limit of detection was 1ng/mL for most hormones. In most cases, there was minimal to no ion suppression in the matrix. This optimized method allows for the analysis and monitoring of reproductive and stress hormones in small samples of *E. robustus* and *B. physalus* blubber. Continued analysis is underway.

Using a novel 'baitSTR' approach to genotype thousands of short-tandem repeats simultaneously – Implications for Sousa sahulensis conservation

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Little is known about genetic population structure of Australian humpback dolphins (*Sousa sahulensis*) along the eastern Australian coastline. Previous data suggested a fragmented metapopulation of four putative clusters with low overall genetic diversity and limited geneflow, resulting in small effective population sizes. We applied a novel approach (baitSTR) to genotype thousands of short-tandem repeat (STR) loci per individual. We generated panels through shotgun sequencing and assembly of a single individual. Putative STR regions were used to design probes based on their flanking regions for capture, sequencing and genotyping of all samples. Using baitSTR, we genotyped a panel of 2499 STR loci for a total of 63 *S. sahulensis* individuals from eight sites along the coast of Queensland, Australia. Of these loci, 2031 were polymorphic with up to 12 alleles. Using this methodology, our analyses identified four major genetic clusters along the coast and significant population structure within the Great Sandy Strait Marine Park with two geographically proximate populations being genetically distinct. Using Bayesian inference, we tested a set of increasingly complex demographic models and inferred demographic parameters including effective population sizes, asymmetric migration rates and population divergence between clusters. We found strong isolation between all genetic clusters with only low levels of directional gene flow from north to south. We demonstrate the immense potential of the baitSTR method to produce massive STR datasets for non-model species, making it a powerful tool to quickly and efficiently assess population genetic parameters in natural populations.

Marine megafauna bycatch in artisanal fisheries in Gorontalo, Northern Sulawesi (Indonesia): An assessment based on fisher interviews.

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While bycatch, the unintentional catch of untargeted species, is one of the main threats to large marine species such as cetaceans, sharks and turtles, fishers can also be negatively impacted by bycatch. Understanding local fisheries profiles, fishers' demography and their opinion is thus a necessary part of the strategy to mitigate artisanal marine megafauna bycatch. Interviews with 112 fishers in nine fishing villages were conducted in January and February 2018 in order to assess the magnitude of marine mammal bycatch, the dependency of fishers on the fishery and the potential for implementation of bycatch mitigation measures in the artisanal fishery in Gorontalo, northern Sulawesi (Indonesia). Quantitative and qualitative methods were used for the analyses. Regression trees showed that cetacean bycatch were mainly influenced by the fishing location. Cetaceans mostly escaped after being caught or were released, resulting in low mortality. Data extrapolation shows that an estimated 1,953 cetaceans are caught annually in artisanal fisheries in Gorontalo of which an estimated 48 animals die. Fishers had large households, typically averaging more than five people, and mostly seemed to be dependent on the fishery, often with few other sources of income. Fishers generally seemed to

favour bycatch reduction measures as bycatch often posed a financial threat rather than a benefit due to lost catch and broken gear. Future actions should include discussions with fishers on reduction options such as gear modification and spatial or temporal management of fishing seasons, coupled with a better understanding on the cetacean ecology and habitat use in Gorontalo.

Modelling spatial habitat use of the Northern bottlenose whale (Hyperoodon ampullatus)

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Habitat use of the bottlenose whale (*Hyperoodon ampullatus*) in the northeast North Atlantic has long remained poorly understood. By establishing species-habitat models to relate shipboard sighting data off the Jan Mayen Island to selected environmental variables, this study aimed to identify significant predictors for bottlenose whale occurrence and provide spatial estimates of potential high-use regions. Covariate effects were examined by fitting Generalised Additive Models (GAMs) respectively to whale occurrence and additional whale sightings given presence, and spatial estimates of the actual number of sightings were calculated from multiplying the model-averaged results (occurrence x whale sightings). Higher occurrence probability was estimated at steeper topography, which is consistent with the deep-water behaviour of bottlenose whales. Likelihood of whale encounter was also positively correlated with concentration of chlorophyll below 0.4 mg m^{-3} and above 1 mg m^{-3}. Temporal lag between the peaks in chlorophyll concentration and whale abundance appeared to be more than two months. The number of additional sightings given presence was predicted to be higher at shallower water depths (<1000m) with steep topography, and deeper water depths between 1000m and 2700m with gentle seafloor slope. Spatial predictions largely corresponded with field observations that indicated high usage around the submarine canyon regions in the east and southeast of Jan Mayen Island. This study provided the first species-specific habitat model for northern bottlenose whales in the northeast North Atlantic. It highlighted the likely importance of bathymetric features in shaping the pattern of habitat use of this deep-diving species. Model predictions could support conservation and management efforts, and inform mitigation measures by minimising spatial overlap between potential high-use areas and anthropogenic activities.

Smooth hammerhead - Pantropical spotted dolphin predation event

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Observing a predation event by a shark on a dolphin is rare and photo documentation is deficient. Different from larger species that sometimes survive attacks, the only way of confirming that they occur on smaller species of delphinid is from actual observations. On the 31st of December 2016 while conducting a dolphin/whale watch ~1km off western Oahu Hawai'i, USA, a smooth hammerhead (*Sphyrna zygaena*) predation event on a juvenile Pantropical spotted dolphin (*Stenella attenuata*) was observed and photo documented. At 10:00 am, in approximately 400m depth, a pod of around 20 spotted dolphins was encountered. As the boat, a 9.75m RHIB, approached the group, many individuals approached the vessel to ride the vessel's wake. Moments later we happened upon an additional ~150 spotted dolphins. At this time, one juvenile began leaping next to the boat with a remora observed on the body. The boat slowed and suddenly a small group (10-20) porpoised around the last spot the juvenile had landed. The outer periphery and seemingly the remainder of the large pod porpoised at a rapid speed in all different directions away from where the others had leaped. Immediately after, a dorsal and caudal fin of a shark was observed, followed by blood in the water. An observer, hanging over the side of the boat, put a camera into the water to document what was happening. The entire body, behind the juvenile dolphin's dorsal fin, was bitten off. Images taken show the shark grabbed the dolphin carcass multiple times from different angles as it sunk, eventually swimming away with it. The predation event lasted approximately 1 minute. In Hawaiian waters only tiger sharks (*Galeocerdo cuvier*) have been documented preying on spotted dolphins. This is the first documented event of a smooth hammerhead shark feeding on a dolphin species in Hawaiian waters.

Are Florida manatees (Trichechus manatus latirostris) wearing their teeth beyond functionality? Interspecific and intraspecific mesowear in manatees.

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Manatees (*Trichechus* spp.) are herbivorous aquatic mammals found in warm waters. At maturity, they possess only supernumerary molars (SM), with 5-8 in occlusion in each quadrant. Manatees exhibit a dental replacement system in which they shed old teeth anteriorly and erupt new teeth posteriorly. This adaptation is thought to have arisen to deal with abrasive foods. Mesowear (facet development on occlusal surfaces of teeth) increases from posterior to anterior. Tooth functionality is linked to level of mesowear, with increased amounts resulting in decreased food-processing ability. Less functional teeth can result in an increase in feeding time, potentially decreasing fitness. Domning (1982) noted that Florida manatees (*T. manatus latirostris*) appeared to experience greater levels of mesowear compared to other manatee populations, however he did not quantify the difference. To address this we examined museum specimens from all manatee taxa: Florida (n=64), Antillean *T. m. manatus* (n=49), Amazonian *T. inunguis* (n=121) and African *T. senegalensis* (n=4) manatees. Photographs of the dental arcade (upper and lower) were taken and analyzed. Each SM in occlusion was numbered (posterior to anterior) per quadrant and classified into one of five discrete wear categories (level 5, extreme, being considered as non-functional). Total number of teeth per quadrant (TNTQ) and total number of functional teeth (TNFTQ) per quadrant were counted including missing teeth (evidenced by dental alveoli). Florida manatees had significantly fewer mean TNTQ ($H=130.03$, $p<0.001$) than other taxa except Antillean manatees, and fewer mean TNFTQ ($H=362.21$, $p<0.001$) than all other manatee taxa. In addition, except for SM1, Florida manatees had greater mean levels of mesowear (SM2-SM6) compared to all other taxa. Florida is not only a marginal habitat for manatees because of seasonally cooler water, but also because of the additional dental burden: where it appears they are wearing down their teeth faster than the replacement process.

Use and usefulness of photographic-identification in studying a growing community of harbour seals (Phoca vitulina) in SE England.

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Globally, harbour seals (*Phoca vitulina*) are displaying large variations in abundance, with many populations in the United Kingdom seen to be in decline. The development of a new, growing population in the Solent region of SE England has been documented since the early 1990s and is currently estimated to contain a minimum of 40 harbour seals. This study initially aimed to utilise photographic identification (photo-ID) in determining harbour seal residency and estimating abundance. Due to the variation in data quality resulting from an extremely muddy study area, the objective developed into also investigating how photo-ID can be used and improved in studying harbour seals in Chichester Harbour.

Photographs were collected during monthly boat-based counts between 2016 and 2018. The pelage patterns of hauled-out seals were examined, resulting in the identification of 106 individual seals. This indicates a much larger harbour seal community than previously estimated for the Solent. Resights were low, but may have been hindered by muddy substrate obscuring pelage patterns. To investigate this further, Chi-square tests were used to compare how often body areas were visible, and thus available for photo-ID, along with the number of times different body areas were used to identify an individual. Seals were identified using markings around the head significantly more than any other area, and identified least by markings on the stomach and flippers. There was an association between most commonly-used identification site and visibility of sites; the head was most visible and most used for identification, whilst the stomach was used least for identification and visible least. The differences in visibility are likely the result of the haul-out environment (muddy tidal flats). This study highlights potential for further use of photographic identification to determine

residency of populations, but emphasised the need for greater standardisation of images to be used for identification.

Calving rate decline in humpback whales (Megaptera novaeangliae) of northern British Columbia, Canada.

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The humpback whale (*Megaptera novaeangliae*) is a globally distributed baleen whale that undertakes long-distance annual migrations between seasonal feeding grounds in high latitudes and breeding grounds in low latitudes. Worldwide humpback populations are widely recognized to be increasing, but recent estimates show variable trends in some regions, including alarming evidence of decline within Alaskan waters in recent years. Here we present early evidence of reproductive decline in the nearby feeding waters of Northern British Columbia (NBC) using fifteen years of photo-identification surveys (2004 – 2018) in the marine territory of the Gitga'at First Nation, a proposed critical habitat area for British Columbia humpback whales. Out of a growing catalogue of 544 humpback whale individuals, 75 were known mothers, 28% of which were seen in 10 or more years of the study. Within this population we observed annual per-capita and per-mother calving rates of 0.006 – 0.05 and 0.06 – 0.50, respectively. Prior to this peak, our data exhibited an 85% probability that calving rates were increasing (mean estimate = 7% per year); following this peak, calving rates have been in decline (-9% per year, 82% probability). The probabilities of increase and decline reported here are compelling early indicators of a possible shift in regional humpback whale demographic rates. The early increase in calving rate we observed in the first 9 years of our study is consistent with population increases that have been concomitantly observed in NBC and elsewhere in the north Pacific. Conversely, the decline we have begun to observe in NBC, which mirrors the 2018 reports from Glacier Bay, may represent a recent change in reproductive rates or calf survival prior to the mother being sampled on the feeding grounds.

Blending science and conservation with science fiction to reach a shiny new audience.

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Many in science and conservation expressed frustration recently when the Nortre Dame fire generated a global outpouring of grief and over a $billion overnight, while many species are quietly going extinct. While conservation issues may never attract such extensive impromptu funding, much can be achieved without serious funding if people are passionate and involved. Unfortunately, scientists and conservationists often struggle to engage with the public, failing to inspire them into relevant conservation action.

Focused outreach is crucial to connecting with target audiences, but requires carefully pairing your message to that audience. Science fiction fans are one audience worth exploring as they often go to extreme lengths and personal cost to support their fandom. For example, the Western Space Drama series 'Firefly' premiered on the U.S. Fox network in September 2002, but was quickly cancelled despite averaging 4.7 million viewers per episode by mid-December. Calling themselves 'Browncoats,' a reference to the show's protagonists, angry fans quickly mobilised enough pressure for closure to force an unprecedented rebirth in the form of the movie 'Serenity' in 2005.

To explore if such passion could be harnessed for conservation, the Facebook page "Vaquita Are Browncoats" was started in June 2014 to connect Firefly fans with the plight of the vaquita, a critically endangered cetacean that had been languishing in relative obscurity. With practically no financial resources, the resulting community grew slowly both on Facebook and Twitter. Although the page could not influence the drastic decline in vaquita numbers due to illegal fishing that unexpectedly resurfaced in 2015, it successfully boosted attention, ultimately being featured at the Sci-Fi convention, FedCon, in Bonn in May 2018. We will review this approach and offer suggestions for possible improvements in other such efforts that may arise in the future.

Habitat and distribution of cetaceans from the first comprehensive survey of coastal and offshore waters in the Canadian Pacific.

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Many cetacean species were depleted in Canadian Pacific waters by commercial whaling, which ended in 1967. Although some populations have since shown evidence of recovery, there is limited information about current abundance and geographic distribution, particularly in difficult-to-access offshore regions. This lack of baseline data hampers conservation status assessments, including estimating population-level impacts of anthropogenic activities. From July to September 2018, we conducted ship-based surveys throughout the coastal and offshore waters of British Columbia, Canada to assess the abundance and distribution of cetacean species. In addition to visual observations, we employed complementary acoustic techniques such as sonobuoy deployments and a towed hydrophone array to locate cryptic and deep-diving species that are frequently missed by conventional surveys (e.g. sperm and beaked whales). The most common mysticetes were humpback whales (n=1164 individuals) and fin whales (n=378), while the most common small cetaceans were Dall's porpoise (n=868) and harbour porpoise (n=405). Six sightings and numerous acoustic detections of sei whales yielded new information about how this species is using Canadian Pacific waters again following its extirpation from the area. Density surface modelling was employed to analyze the distributions of species throughout the surveyed habitat. We found that baleen whales showed partitioning of habitat use, with fin, sei and blue whales populating the offshore region and humpbacks associating with continental shelf and coastal areas. Our results can be compared with historic whaling catch data to determine the extent of recovery of previously harvested populations, which will have important ecosystem-level implications as these predators return to habitats from which they were previously extirpated. Survey results will also inform management decisions such as Potential Biological Removal limits for fisheries bycatch and entanglement mortality, and will improve the effectiveness of Marine Protected Areas as tools for cetacean conservation.

Rapid sea-ice loss results in shifting distributions of Arctic and sub-Arctic marine mammals: Evidence from passive acoustic data in the eastern Bering seascape.

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Rapid sea-ice loss in the Arctic has resulted in extended open water periods, which provide an opportunity to test hypotheses about the effects of environmental drivers, such as sea-ice onsent and retreat, on species occurence. To gain inference into the effect of these drivers, we manually analyzed 103,010 hours of data from nine passive acoustic recorders stationed along the eastern Bering shelf from 2012-2017 (~30% duty cycle) for the presence of four marine mammal. Migratory timing and extent of range of bowhead whales (*Balaena mysticetus*) and Pacific walrus (*Odobenus rosmarus divergens*) coincided with the onset and cessation of sea-ice over the shelf regardless of date of ice formation or retreat, resulting in abbreviated occurences in reduced ice-years. Walrus calls were absent from stations without ice, regardless of detections at those stations in prior years, supporting the conclusion that the walrus is as an ice-obligate species. In contrast, bowheads were detected annually at stations in the Northern and mid-Bering regions regardless of ice presence, suggesting a decoupling of ice and bowhead presence early in the season. Nevertheless, calling was brief at mid-Bering stations in reduced or ice-free years, suggesting that bowheads overwintered in ice-associated waters in the Northern Bering. Detections of humpback (*Megaptera novaeangliae*) and critically endangered right whales (*Eubalaena japonica*) spanned open water periods until ice formation. Additional brief and intermittent detection of humpback whales at southern stations during winter months of reduced/absent ice years suggest possible overwintering. Furthermore, overlap of humpback and bowhead whale detections increased at one Northern Bering station to 44 days in 2015 compared with 8-23 days in prior years. Taken together, these observations indicate that important shifts in the spatial extent and seasonal occurence of Arctic and sub-Arctic marine mammals have occured during a period of rapid sea-ice loss.

Computational fluid dynamics analysis of gliding North Atlantic right whale models with variable body shapes.

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The streamlined body shapes of cetaceans delay the separation of flow, create lower drag when they swim, and therefore decrease their locomotor cost in terms of energetics. However, previous studies show that body shape of the North Atlantic right whale (Eubalaena glacialis; hereafter right whale) changes with life stages, reproduction status, nutritive conditions, and the effects of entanglement. In addition, results from our previous work indicate that drag on right whale varies with position due to its irregular outline. Accordingly, in this study, we aimed to investigate the changes in drag on right whales with variances in body shapes and estimate any associated kinematic costs. Based on our results, we hypothesized that emaciated right whales, which have a less-streamlined body configuration such as having concavity in the post nuchal area, suffer higher drag when swimming and consequently need longer time to recover from previous encounter with fishing gear or replenish their energy reserves. This fact is likewise crucial for pregnant females because their energy budget for migrating to breeding grounds may increase due to having an enlarged girth for their abdomen. To obtain measurements of drag over right whales under various body conditions, we undertook computational fluid dynamics (CFD) simulations on several static right whale models reflecting different body fitness (e.g., normal condition, emaciation due to entanglement or low prey availability, and pregnancy, etc.) and measured multiple fluid dynamics parameters such as characteristics of boundary layer, drag, drag coefficients, and other forces on the animals. Our results reveal that drag on right whales fluctuates across its body and is higher at positions facing incoming flow, suggesting that the kinematic energy expenditure of right whales is indeed affected by its body shape and that the body shape of right whale should be measured and analyzed carefully when assessing their health conditions.

A low-order model of dolphin swimming dynamics: Fluke flexibility and energetics.
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This work presents a physics-based, low-order model of the swimming dynamics of a bottlenose dolphin, which captures critical features such as body posture, fluke flexibility, and delayed fluke stalls (Fish & Rohr 1999). The model integrates data and findings from previous research on odontocete cetaceans, including body morphometry, fluke morphology and elasticity (Fish et al. 2006; Fish et al. 2007; Gough et al. 2018), flipper hydrodynamics (Weber et al. 2009), and swimming gait and stability (Fish et al. 2003; Rohr & Fish 2004).

The modeling framework is based on a mixed Newtonian-Lagrangian formulation, first proposed for the modeling of aircraft with uni-dimensional flexible elements (Avanzini et al. 2014), and brings together tools and concepts from multi-body dynamics, plate theory, hydroelasticity, and unsteady hydrodynamics. The head, torso, caudal peduncle, and pectoral fins are modeled as a set of interconnected rigid bodies, with the peduncle elements being subject to a prescribed gait profile relative to the torso. The fluke, on the other hand, is modeled as a flexible plate, whose deformation evolves in response to the fluke's hydrodynamic, elastic, and inertial forces. Because hydrodynamic loading over the fluke is in turn affected by its deformation state, the model incorporates results from unsteady thin-airfoil theory and unsteady lifting-line theory to predict lift, drag, and pitching-moment distributions over the deforming fluke.

This model represents a versatile tool to investigate marine mammal biomechanics and swimming energetics. Here, we present a set of comparative studies that examine the impact of fluke flexibility and unsteady hydrodynamics on thrust generation and swimming efficiency. We also analyze active mechanisms for body and rostrum stability during swimming. We expect that the knowledge gained from this modeling effort will inform and support the development of algorithms for the reliable estimation of locomotion costs from bio-logging tag data.

Comparison analysis of color patterns between two subspecies of common minke whales (Balaenoptera acutorostrata).
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We compared color pattern differences between two subspecies of common minke whale (*Balaenoptera acutorostrata)*: North Atlantic minke whale (*B. a. acutorostrata*) and North Pacific minke whale (*B. a. scammoni*). The aims of this study were to clarify color pattern differences between these two subspecies and contribute to the phylogenetic knowledge. We used 18 North Atlantic specimens and 84 North Pacific specimens collected from offshore waters near Norway and Japan. We observed sexually mature females only. Observation points were the head, flipper, lateral field, peduncle field, and caudal fin. In terms of the flipper, we measured three points and only the left flipper was used. We used photographs to analyze the other observation points. On the head, dark throat patches and dark dorsal fields extending to the ventral grooves were observed in all individuals in both specimens. On the flipper, the mean angle between the tip of the flipper to the end of the articular process of the humerus and proximal boundary line of the white patch was larger in the North Atlantic specimens. The proximal boundary lines of flipper white patches were straight in the North Atlantic specimens but curved in North Pacific specimens. North Atlantic specimens showed streaks, eddy patterns in the lateral field, and counter shading with sharp distinctions. On the other hand, most of North Pacific specimens showed no streaks or eddy patterns, and gradual change in color. North Pacific specimens had double caudal chevrons but North Atlantic specimens showed one or zero chevrons in most individuals. North Atlantic minke whales also had concentric circular patterns on the caudal fin. Based on the color pattern differences observed in the two subspecies for this study, cladistic analysis would place the North Atlantic minke whale (*B. a. acutorostrata*) in the same clade as the dwarf minke whale (*B. a. subsp*.).

Helicobater pylori infection in South American sea-lions (Otaria byronia): High risk of human transmission.

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Gastro-enteric diseases are commonly associated to marine enteric zoonotic bacteremia, though transmission of anthropogenic diseases to marine life is poorly documented in Peru. *Helicobacter pylori* is the most common gastric bacteria reported in the human population of this country, considered an endemic disease. The objective of this presentation is to demonstrate the presence of *H. pylori* in South American sea-lions (*Otaria byronia*) as the closest marine species to a compromised human population. Live stranded sea-lions were admitted at the South Pacific Marine Mammal Center in Lima, gathering age class, gender, location and stranding cause. Blood samples were collected from specimens with clinical signs of gastroenteric disease (n=36) for immune-globulin reaction to *H. pylori* antigen: IgM for positive presence and IgG for previous exposure to the bacteria. Clinical signs in positive patients to *H. pylori* included abdominal discomfort, indigestion, high acidity, diarrhea, melena, hemorrhagic gastritis focalized in the pyloric region of the stomach, and severe anemia. Biopsies collected from patients positive to *H. pylori* were assessed using immune-histochemical stain. 87% of sampled cases were positive to *H. pylori.* Findings included necrosis of the gastric epithelium, local inflammatory reaction with high lymphocyte aggregation and loss of continuity solution in the shape of eroded elongated cavities in the pyloric mucous typical of this bacterial disease. Secondary gastritis is commonly associated to sea-lion strandings, though patient recovery requires a long-term antibiotic treatment for those positive to the bacteria. Lima is the largest coastal city in the country and risk of transmission to the local sea-lion population must be address on the epidemics of gastro-enteric diseases, and include public health campaigns. As part of an extensive health assessment of local marine mammal populations, *H. pylori* diagnose has been included in the regular admission protocol, becoming critical for live stranded individuals.

Peculiar morphology of the stomach of several beaked whale species known from the western North Pacific.

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Morphology of the beaked whale stomach is intriguingly specific. Mead (2007), in his extensive and explicit study, proposed a classification of the beaked whale stomachs consisting of three types; 1) generalized (1 main stomach and 1 pyloric stomach), 2) derived stomach type I (2 main stomachs and 2 serial pyloric stomachs), and 3) derived stomach type II (2 main stomachs and 2 pyloric stomachs; PP&PA). We made gross morphological observations on the stomachs of 4 species of beaked whales of 3 genera

(*Berardius*,*Indopacetus*and *Mesoplodon*) that were not included or only briefly described in Mead (2007). Histological observations were also made on a very fresh individual of *M. carlhubbsi*. As a result, stomachs of the species observed in the present study are classified into: type II (*Berardius*sp. with 8 connecting chambers (CC) and *Mesoplodon ginkgodens*with 11 CC); 1 main plus 2 serial pyloric stomachs (*I. pacificus*with 5 CC); and modified type II (*M. carlhubbsi* with 10 CC). The stomach of *M. carlhubbssi*is very special, where the main stomach is faintly separated into two spaces (main stomach and accessory main stomach), and the distal portion of the accessory main stomach having a "cancellousstructure" separated by a network of interconnected trabeculae. Among 4 individuals of *M. carlhubbssi*, two were infants and their stomach structure was almost identical to that of the adult individuals.Histologically, both main stomachs are lined by a simple columnar mucus-secreting epithelium, with abundant parietal and chief cells in the mucosa. The epithelium of the connecting chambers through to the pyloric stomachs on the other hand, is continuous and constant with mucous cells organized into pyloric glands. The diversity of ziphiid stomachs may represent their phylogenetic background, and further comparative considerations with genetic phylogeny is necessary.

Target region selection for characterization of the microbiota of beluga (Delphinapterus leucas) by 16S MiSeq sequencing

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The taxonomic characterization of bacteria is usually based on amplification of 16S rRNA gene sequences. The Illumina MiSeq sequencing has extended the read length to 300 bp paired-end reads in a single run, enabling deep sequencing for plenty of samples. The V1–V3 region of 16S rRNA gene has been used as a genetic marker for bacteria, while more studies have used this technology for various microbiome studies targeting the 16S rRNA V3–V4 hypervariable region. However, there is no study on the selection of appropriate 16S target amplicons for cetacean microbiota. The aim of this study was to test the experimental applicability of V1–V3 and V3–V4 primer pairs by comparison of taxonomic coverage and target specificity in cetacean studies. Fecal and blowhole samples from 18 sampling in captive beluga whales (*Delphinapterus leucas*) were used for analysis using MiSeq platform. It shows that the V1–V3 presents higher species richness (Chao1 and observed species) than the V3–V4, but there was no significant difference between them in specie evenness (Shannon and Simpson). In blowhole samples, the V1–V3 appeared to observe more *Flavobacterium*than V3–V4. The V3–V4 appeared to contain more *Varibaculum*and *Taylorella*than found in V1–V3 region. In Fecal samples, the V1–V3 appeared to contain more *Lachnoclostridium*than found in V3–V4. It is therefore important to use primers targeted to these two regions of the 16S rRNA gene in all deep-sequencing efforts to obtain representational characterization of microbial communities.

A late-season survey reveals large numbers of humpback whales in the Northwestern Hawaiian Islands.

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In April 2019, the NOAA Pacific Islands Fisheries Science Center and Hawaiian Islands Humpback Whale National Marine Sanctuary conducted a collaborative exploratory ship-based survey for humpback whales (*Megaptera novaeangliae*) in the Northwestern Hawaiian Islands. The 6-day effort surveyed shallow atolls and banks extending from Middle Bank (north of Kauai) to St. Rogatien Banks (north of French Frigate Shoals) and included visual observations and passive acoustic monitoring. Acoustic methods included the deployment of sonobuoys for detection of singing whales in shallow waters and use of a towed hydrophone array for detection between islands and atoll areas and during nighttime transits. We sighted approximately 180 humpback whales, primarily in waters less than 100 m depth, and acoustically detected many singers in shallow waters and during nighttime transits. Whales were also observed transiting between banks. Encounters included at least 13 calves, with several competitive groups at each of the surveyed areas. When feasible, whales were approached for the collection of individual identification photos and biopsy samples. At least 47 individuals were identified with fluke images and 10 biopsy samples

were collected from adults (including 3 pairs of samples from mom-calf-escort triads). This survey builds upon a 2007 visual and passive acoustic ship-based survey and other extensive passive acoustic data that indicated humpback whales use this portion of the archipelago. Our effort resulted in a much higher encounter rate than the previous survey, as well as the collection of adequate photo-ID and tissue samples to examine connectivity of whales in the Northwestern Hawaiian Islands with those in the main Hawaiian Islands and other breeding and feeding locations in the North Pacific.

Receiving sensitivity about the amplitude and frequency of the hydrophones attached to acrylic plate ― Towards simplification of dolphin sound study at aquariums, 2 ―

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Sound recording system for captive aquatic animals, especially dolphins, in a tank needs to give care to the environmental enrichment. Recently it is improved that small hydrophones are attached outside on the acrylic glass of the tank (AQH100k-DTP, AquaSoundCo.). Here we evaluated about the sound transmission loss and modulation characteristics of the acrylic plates for three different thicknesses (15, 20 and 30 mm) at source frequency in range between 3 and 130 kHz. The amplitude of the output from the attached hydrophone was measured by an oscilloscope (TBS1064) and simultaneously recorded in an audio-recorder (EZ7510, Sampling-rate 500 kHz). The modulation was analyzed by an audio-software (Audition6.0). The frequency spectrum was calculated for the recorded signals by the FFT (size: 1024, Hamming window), after was taken noise-reduction at once. Results show no significant correlations between acrylic plate thickness and the sound transmission loss for every frequency. In addition, the loss increased at 3-40kHz, while it shows negative values between 50-130kHz regardless of the plate thickness. The former increased loss is due to the negative reflection at the interface between water and air. The latter gain is due to the sensitivity enhancement of the hydrophone's mechanical Q value. Results also show no significant correlations between acrylic plate thickness and the frequency modulation for every frequency. In addition, the frequency modulation appeared at the region 3-10 kHz, 80-130 kHz, while it was not recognized at 13-70kHz for any plate thickness. The maximum amplitudes appeared at 90kHz at any plate thickness and source frequency. The frequency modulation is affected by the mechanical noise of the recorder. The frequency ranged 3-10 kHz and 80-130 kHz is strongly affected by the high-noise regardless of the plate thickness. It needs careful analysis on transmission loss for recorded aquatic animal sounds by using the outside-attached hydrophone.

A whale of a tale: A 3-year study of metals in Gulf of Maine whales.

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The Gulf of Maine is an important body of water for both humans and marine life, located on the Eastern seaboards of the United States and Canada. It is an important marine nursery, feeding ground and sanctuary, with over 3,000 marine species living there. At the same time, the Gulf of Maine is an area with heavy coastal development, industry, and marine traffic, all of which contribute environmental chemicals to the Gulf resulting in chronic exposures of the people, animals and ecosystem that depend on the Gulf of Maine. The whales in the Gulf of Maine are a valuable sentinel species for pollution in the Gulf as they integrate all possible exposure routes and are key species integral to the health of the people, ecosystem and economies of the region. We collected whale skin biopsies for three seasons (2010-2012) and measured the levels of 25 essential and non-essential metals in three whale species: humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), and a minke whale (*Balaenoptera acutorostrata*). Overall, the general pattern of metal accumulation was consistent across species. As expected, we found the levels of the essential metals iron (Fe), magnesium (Mg) and zinc (Zn) to be among the highest levels for the metals we observed. Some metals of public health concern, aluminum (Al), nickel (Ni) and chromium

(Cr), were also among the highest levels, while others, arsenic (As), cadmium (Cd), cobalt (Co), lead (Pb), mercury (Hg) and uranium (U) were comparatively low. Comparisons with similar species from other regions indicate humpback whales have levels of genotoxic metals (i.e. DNA damaging) that are among the highest in the world. These data indicate metal exposure may be a significant health concern for the Gulf of Maine ecosystem. This work was supported by NIEHS grant ES016893 (J.P.W.).

Changes in harbor porpoise nutrition during an ocean warming event

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n 2013, a mass of unusually warm water, known as "The Blob" was detected along the Pacific Coast of North America and persisted into 2016. The phenomenon dissipated later that year, but a new marine heatwave was detected in June of 2019. The effects of the Blob on local fauna are still being studied, and the population of harbor porpoises (*Phocoena phocoena*) off the coast of California is an ideal candidate for further investigation. Since they are non-migratory, their trophic history can offer insight into how feeding opportunities and trophic composition changed during the warming event. I will document changes in the foraging ecology of harbor porpoises that stranded from 2011-2018 along the coast of California using stable isotope analysis and nutrition characteristics. A better understanding of the foraging histories of cryptic cetaceans preceding, during, and after an extreme event could help managers gain insight into these events in the future.

Behavioural responses to human disturbances at a recently-established designated Atlantic grey seals haul-out site (Halichoerus grypus)

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The Ythan estuary was recently included as a designated haul-out site for grey seals on the East coast of Scotland. This followed rapid growth in the number of seals utilising the site year-round. The Ythan estuary is also a favoured destination for recreation and leisure – as well as being directly below the take-off and landing path for helicopters navigating between Aberdeen airport and the offshore oil and gas installations. We need to understand how these human activities influence seal haul-outs to appropriately manage the important site.

This study sampled the behaviour of focal individual grey seals hauled out at the Ythan site during the post-breeding season (July–September 2017, n=420) and during the moult (January-March 2019, n=454) using ad-libitum sampling of behavioural events associated with responses to disturbances.

Grey seals were more likely to scan during post-breeding. In all cases, scanning was increased in the presence of dogs. Vigilance depending on the number of people on the beach also changed during weekends and school holidays. Seals at the back of the group, and those orientated away from the public were more likely to be disturbed – and this occurrence increased with increasing numbers of people and dogs. Interestingly, there was little effect of helicopter presence – except for juvenile seals.

Seals were rarely flushed into the water and this was more likely when people approached the seals from the closed beach area or when dogs entered the water. Human activities affect seal behaviour at this site, this despite those human activities pre-existing the site colonisation by seals. The physiological impacts of flushing during the moult are non-trivial. In addition, the variation in behavioural response between the two periods shows that those responses do incur a cost that may be harder to meet during the moult when seals are energetically constrained.

Global marine mammal bycatch in fisheries: Dispelling the myths and identifying the challenges in implementing the Marine Mammal Protection Act Import Provisions.

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The United States' Marine Mammal Protection Act (MMPA) states that the United States shall ban the importation of foreign commercial fish or fish products which have been caught with commercial fishing technology which results in the incidental kill or incidental serious injury of marine mammals in excess of United States standards, or of any fish or fish product that was produced in a fishery that intentionally kills marine mammals in the course of those fishery operations. Under this regulation, NOAA Fisheries, in consultation with foreign trading partners assembled a List of Foreign Fisheries (LOFF). This LOFF contains global fisheries information for fisheries that export seafood products to the United States, including the target catch, gear type used, number of vessels or participants, area of operation of the fishery, and data regarding incidents of marine mammal interaction in the course of commercial fishing operations. Based on the fisheries on the LOFF, in July 2019, nations submitted Progress Reports outlining the steps they are taking to develop regulatory programs to mitigate marine mammal bycatch in their export fisheries. This information was submitted through the NOAA Fisheries International Affairs Information Capture and Reporting System data portal. Now, nearly three years into the implementation of the MMPA Import Provisions we have identified the fishing areas and gear types with the highest marine mammal bycatch. Stationary gear such as gillnets, set nets, and pound nets disproportionally entangle and kill marine mammals more than actively fished gear types. Areas with high marine mammal bycatch are more likely to be those with high gillnet use. Stationary gear represents the greatest challenge for bycatch mitigation while longline, purse seine, and trawl gear is more amenable to safe handling and release standards and best practices, all of which can reduce bycatch. High-seas pelagic fisheries represent a lower bycatch risk

Investigation of habitat preference of Risso's dolphins by using maximum entropy modeling in Eastern Taiwan

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The information of spatial distribution and habitat preference of a wildlife species is the fundamental information for conservation and predicting its possible response toward environmental changes or anthropogenic threats. Although Risso's dolphin (*Grampus griseus*) is one of the most common cetacean species off the eastern coast of Taiwan, the knowledge on its distribution pattern is still limited. In this study, we took whale-watching sighting records during the years of 1998-2014 at two areas in the eastern coast of Taiwan. We used ecological niche modelling (Maxent) to analyze the habitat preference of Risso's dolphins with topographic and climatic features (depth, slope, the distance from coast , the distance from river mouth, and SST). Our results suggest that Risso's dolphins frequently occurred in deep water habitats along the edge of continental shelf in the study area. The important variables associated with their distribution include water depth, the distance from river mouth and sea surface temperature. This preference for steep and warm waters is consistent with other studies of the same species off California, in the Mediterranean Sea and the Gulf of Mexico, and may related with their food sources of squids. This study reveals that data from citizen science is able to provide useful information on cetacean spatial ecology.

What's with all the buzzing? – Propagation and potential function of short burst pulses produced by resident-type killer whales (Orcinus orca).

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Killer whales in many parts of the world produce pulsed calls that are characterized by stereotypical component structures allowing listeners to distinguish different call types. Due to their high pulse repetition rates some components become tonal. Tonal components often produce distinct frequency contours in spectrograms and therefore have been considered important in social communication. Call components with lower pulse rates or '*buzzes'* have received less attention than their tonal counterparts. Buzzes often occur at the beginning of calls and have been described as introductory notes that may capture the attention of a receiver who then can tune into the information that follows. Alternatively, buzzes may be means to prepare or tune the pulse generating apparatus to produce sounds with high pulse repetition rates that have a tonal quality. Some calls, however, can occur either with or without initial buzz components, while the types and order of the tonal components remains unchanged. On the other hand, buzzes can occur independently without being followed by tonal components. Also, the spectral composition of buzzes shows distinct variations in

sound energy across the frequency domain of these broadband signals. The variation is structured and recurring peaks at increasing sound frequencies are present. We tested the propagation of buzzes produced by a pod of *resident* killer whales in waters off British Columbia during field experiments and found them to travel considerably further than tonal sounds contained in the same sequence of calls in various ambient noise conditions. Buzzes may allow killer whales to stay in contact over greater distances, especially in noisy environments and may play a distinct role in social communication different from that of the tonal components of calls. The occurrence of buzzes at the beginning of calls may underline their role as markers of an important transmission.

Threatened coastal dolphins in southern Brazil: Expert elicitation as a tool for area-based marine conservation.

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The coastline of southern Brazil harbours an extremely rich biodiversity, recognised by the presence of a natural World Heritage Site. Even though this area holds many crucial habitats for marine megafauna, it is also being threatened by a wide array of coastal anthropogenic activities that inevitably impact marine ecosystems. Among the present marine megafauna, top predators such as coastal cetaceans play a crucial role in the ecosystem functioning and health. Resident populations of small cetaceans depend on the coastal habitats for reproduction, nursing and foraging throughout their entire lifecycle. Some of these coastal dolphins are considered critically endangered and vulnerable within Brazil, such as Franciscana (*Pontoporia blainvillei*) and Guiana dolphin (*Sotalia guianensis*) respectively. Even though ecological and biological data about these populations exist, there is still a severe lack of spatial data for conservation strategies. In order to fill this knowledge gap, spatial rapid assessment has been conducted through expert elicitation, placing existing ecological data in space, integrating this with layers of anthropogenic activities, and thus exposing potential cumulative impacts and critical areas. Therefore, a workshop series is being organised to identify and map distribution of both dolphins and anthropogenic activities along southern Brazil. A first pilot workshop organised in November 2018, highlighted novel ecological data, such as dolphin occurrences on the coastal shelf, and over 20 anthropogenic stressors were listed. These workshop results are being complemented by a vulnerability assessment collected through an online survey, forming the baseline information for a second workshop in May 2019, which will be conducted with experts. Until December 2019, these results will provide a broader perspective on ecological issues and vulnerability of these dolphins, highlighting priority areas for conservation, and supporting future spatial planning efforts.

Trace element concentration in blubber biopsies of Humpback whales (Megaptera nevaeanglae) from Madagascar: Gender differences and correlation between different elements.

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Contaminants monitoring in wild, large cetaceans may be performed using internal organs of stranded animals. Although extremely valuable, data obtained from dead animals can be biased by poor health conditions, modifying the concentrations of pollutants. Blubber biopsies represent the most feasible sampling technique from free ranging Mysticetes but are little used for trace elements quantification. Blubber biopsies from humpback whales (*Megaptera novaeangliae*) have been used to quantify most relevant trace elements (Hg, Cd, Pb, As). Samples were collected during the months of July and August 2014 in the North East of Madagascar, near the Island Sainte-Marie. Sex of the animals were genetically determined. For trace

elements quantification, samples were microwave digested and analyzed using an Inductively Coupled Plasma-Optic Emission Spectroscopy. Obtained data underline a reduced exposure to contaminants, which is not surprising considering the trophic level of humpback whales. Some sex-related differences (T-test, $p<0.05$) were observed for Hg and Cd, with males presenting double amounts of both elements than females (0.088 mg/kg vs 0.047 mg/kg and 0.005 mg/kg vs 0.002 mg/kg respectively). This result is comparable to what can be observed with persistent, organic compounds, and can be explained by element release during lactation. Concentrations of Hg, Pb and As are correlated between individuals in males, whereas As and Hg are not in females. The concentration of Cd is not correlated to the 3 other elements, in both males and females. This can reflect either different exposures to the elements or different accumulation and elimination pathways. We think that analyzing the accumulation of trace elements in humpback whale blubbers may represents a very relevant proxy for monitoring the health status of the population, likely correlated to migration routes and to feeding area localization. Our results will therefore have impacts both in terms of humpback whale ecology and conservation.

Measuring wild cetacean body temperature via blowholes using infrared thermal imaging from a drone

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Body temperature is a key health indicator for terrestrial mammals. Thermal measurements of cetaceans have only been done in captivity or with stranded individuals. Internal blowhole temperature of captive dolphins has been shown to be a reliable method for monitoring internal body temperature, but this has not been verified with large, wild cetaceans. We investigated whether drone-based infrared thermography can be used measure internal body temperature of large wild whales by aiming a thermal camera straight down the blowhole apertures from a height of 10 m or higher. We flew an Inspire 1 with a FLIR Zenmuse XT to shoot thermal still images and a Matrice 210 with a FLIR Zenmuse XT2 to shoot thermal video. 48 flights were flown to collect thermographic measurements of relative body temperature in humpback whales (*Megaptera novaeangliae*) on Stellwagen Bank, Massachusetts in 2018 / 2019. FLIR Tools were used to measure a thermal window (>10 x 10 pixels) of the blowholes. Preliminary analysis indicates that looking straight down into a whale's blowholes with a thermal camera may represent an effective and non-invasive method for determining the internal body temperature of cetaceans. However, high variability in measured temperatures indicates a need for extensive flights and trials with different thermal systems to validate the precision of this method. Measurements may not represent true internal body temperature (accuracy depending on limits of imaging sensor up to ±5C) but can be used to measure and compare relative temperatures. The accuracy on internal body temperature measurements may be influenced by atmospheric conditions like cold air cooling the nasal mucosa membrane. These findings help validate the use of drone-based thermal imaging for *in situ* measurements of body temperature of large whales and provides incentive to further explore the uses of aerial thermal imaging for marine mammal health assessments.

Marine animal prosthetics design challenge: Using marine mammals to engage non-traditional audiences in science, technology, engineering, and math.

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Women are often underrepresented in science, technology, engineering, and math (STEM) fields in the United States and elsewhere around the world. At the same time, appreciation of animals cuts across gender and socioeconomic boundaries. Therefore, subject matter involving animals can be used to attract and involve many students that might not otherwise be interested in STEM.

The National Marine Life Center (NMLC) uses marine mammal topics to engage students, including girls and other underrepresented audiences, in STEM. Lessons involving marine mammals aren't limited to the biological sciences. Using marine mammals as subject material, we address topics ranging from science to technology, engineering to math, as well as art and language arts. Marine Animal Prosthetics: An Engineering

Design Challenge is a lesson plan that NMLC developed to excite students about engineering. Designed to meet the U.S. Next Generation Science Standards, the lesson connects disciplinary core ideas – life sciences, earth sciences, physical sciences – with technology and engineering. Additionally, the lesson offers opportunities to connect issues of marine mammal science with art and culture will also be addressed. The lesson was piloted to teachers who participated in a Wade Institute for Science Education Summer Professional Development Institute and refined through an Engineering Day event at public elementary schools in Bourne, Massachusetts. The program is now implemented as part of NMLC's regular educational programming.

Contribution to knowledge of ecology of cetaceans in the Black Sea.

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The cetaceans are at the top of the food chain in the Black Sea and as the largest predators their populations can be a good indicator of the overall condition of the marine environment. Three species of Odontocetes (dolphins and porpoise) occur in the Black Sea – Black Sea Common Dolphin (*Delphinus delphis* ssp. *ponticus*), Black Sea Bottlenose Dolphin (*Tursiops truncatus* ssp. *ponticus*) and Black Sea Harbour Porpoise (*Phocoena phocoena* ssp. *relicta*). Cetaceans are vulnerable to various factors such as water pollution, food shortages, microbial contamination, habitat loss, interactions with fisheries. Against the backdrop of global changes, significant pressures from human activity contribute to the deterioration of living conditions for marine ecosystems. The cetaceans' conservation is seen as a significant challenge worldwide, especially in isolated water basins as the Black Sea. In this regard, we present an attempt to gather comprehensive data on the biotic and abiotic environment in the Bulgarian Black Sea. Through the application of different scientific methods we present a preliminary data on the ecology of cetaceans, their interactions with fisheries, assessment of the trophic state of the environment in model areas and the pressure of some pollutants. A set of particular data on potential and direct negative impacts on the cetaceans in the Black Sea including toxic pollutants accumulation in sediments, food chains and mammals themselves are presented. Data are discussed in regard with conservation ecology aspect.

Can Important Marine Mammal Areas (IMMAs) be used to assist in identifying areas of "high risk" for ship strikes mitigation?

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Important Marine Mammal Areas (IMMAs) are a place-based conservation tool identifying discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation.

Ship strikes involving odontocetes and mysticetes are reported globally, causing both temporary and lethal wounds. Fin whales are the species most often struck by vessels throughout the world's oceans, and there are concerns about the high collision rates for the isolated sub-populations of fin and sperm whales in the Mediterranean.

There is currently no universal technological solution to prevent ship strikes, and the most effective overall mitigation measures are to avoid high risk areas (defined as whale suitable habitat/high density areas interested by high traffic levels) and/or to restrict speed to 10 knots or less to reduce fatal collisions with large whales.

Efforts are being undertaken to assess whether IMMAs can be used as management tools to better delineate high density whale areas for the evaluation of the potential high risk areas for ship strikes.

In particular, IMMAs that contain species or populations vulnerable to ship strikes, and that are transited by significant shipping, could be "flagged" for further investigation of ship strikes events. These include the evaluation of strandings, ship traffic density analyses, and of the potential to

implement mitigation through avoidance or speed reduction.

The IMMA workshop organized in 2016 in collaboration with ACCOBAMS in the Mediterranean Region identified a total of 26 IMMAs, of which eight with large whales as primary species. These IMMAs can be used as tests to evaluate this methodology, by overlapping shipping routes to indicate areas with higher likelihood of ship strikes events. These areas can enhance conservation efforts on marine biodiversity and ecosystem health, leading *inter alia* to mitigation of human impacts and threats to large whales, through appropriate IMO measures.

Studio Porpoise, a novelty for science and tourism.

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In 2017 Studio Porpoise was installed at the jetty of Zierikzee in the former Dutch Eastern Scheldt estuary. This area, in which about 50 harbour porpoises (*Phocoena phocoena*) live, is now semi-enclosed by a storm surge barrier.

One study shows that this water contains 5 relatively deep areas (50-60m) where the chance to find porpoises and its prey is above average, 'caused by the tidal turbulence and the abundancy of nutrients'. At one of these hotspot locations, a buoy with a hydrophone and transmitter were placed 200m from the jetty. On the jetty a pillar containing a sound receiver, data recorder and speakers were placed. This unique novelty serves two purposes. One is to show the public the uniqueness of having a cetacean species in the Netherlands, which can be observed simultaneously by ear and eye. Since the installation, 1000's of people have been listening here to the sound of porpoises. The studio's uniqueness was reason for the International Whaling Commission to make it a case study in their recently issued IWC handbook.

The other purpose is to learn more about the species itself. The effect of abiotic and biotic factors on the presence of the harbour porpoise has been studied. The recorded acoustic data, by using Pamguard software, shows that not only the currents are important for attracting prey for the porpoises, but the ship movements of local boats nearby may also be of importance. For now, we notice that most porpoise activity is almost absent here, possibly due to the sound disturbance in the morning. In the afternoon when boats are less present and, in the evening, even absent, the occurrence of porpoises increases. This is now further investigated in order to see if porpoises are affected by sound disturbance even when the prey abundancy is high.

Shedding light on common minke whales in the Gulf of St. Lawrence, Canada: Photo identification, effects of biopsy sampling and exposure to contaminants.

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The common minke whale (*Balaenoptera acutorostrata*) is the most abundant mysticete in the St. Lawrence Estuary and its gulf and a seasonal visitor in this important feeding area at the East Coast of Canada. Our knowledge about the structure and size of this population as well as its exposure to environmental contaminants is very limited. Since 2001, we have been conducting a long-term study on minke whales of the St. Lawrence Estuary. A catalogue that currently contains 249 individuals has been established using state-of-the-art photo identification software, and biopsy samples are carried out annually since 2015 using a low-powered crossbow and adapted biopsy darts. In order to assess the short- and medium-term impacts of this biopsy sampling method, multiple behavioral focal animal observations were conducted before and after each biopsy sampling. These biopsies of skin and blubber were analyzed for a series of potentially toxic PBDEs and emerging halogenated flame retardants in order to better understand their bioaccumulation. Transcriptomic analyses were also conducted to investigate on potential effects of these contaminants on this population. Results of our focal animal monitoring suggest that biopsy sampling using a minimally invasive crossbow-dart technique has only short term effects on minke whales. Chemical analyses indicated elevated concentrations of PBDEs and certain emerging halogenated flame retardants in blubber of minke

whales. In addition, gene transcripts involved in the regulation of steroid hormone pathways were associated with several xenobiotics. To our knowledge, this is the first study to investigate the linkages between concentrations of any contaminants and genomic markers of endocrine regulation in this highly contaminant-exposed cetacean population. Although the minke whale population of the St. Lawrence Estuary is not currently at risk, exposure to environmental contaminants could ultimately have a significant impact on the state of health and reproduction of this population.

Understanding vocal behavior of right whale mother-calf pairs to inform passive acoustic density estimation.

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A baseline understanding of vocal behavior in baleen whales is a vital first step for passive acoustic density estimation. Here we describe call type and call rate variability for southern right whale (*Eubalaena australis*) mother-calf pairs and characterize the probability of acoustic detection on the calving grounds. The southern right whale is a valuable model system because concurrent visual and acoustic observations of multiple mother-calf pairs can be conducted close to shore. In particular, this has implications for monitoring mother-calf pairs in the Southern Atlantic. Additionally, southern right whales can be used as a proxy for understanding the behavior of highly endangered North Atlantic right whales. For this study, we deployed four suction cup tags and moored hydrophones for 32 days of acoustic recording, as well as used a theodolite to collect 28 days of visual survey data concurrent with acoustic recordings in the Right Whale Environmental Protection Area in Ribanceira Bay, Santa Catarina, Brazil. Using these data, we modeled sound propagation in this environment and compared visual estimates of abundance with recorded calls. Additionally, we report on variation in call types and rates within the bay. These data can be used to inform acoustic density estimation parameters. Over the course of the field study, we recorded abundance estimates from visual surveys of 9 to 21 groups (mother-calf pairs or lone individuals) in the bay each day. The understanding of call rate and how it varies with whale abundance will provide important insight necessary for robust estimations of density using passive acoustic data.

Acoustic presence of bottlenose dolphins (T. truncatus) around a fish farm in the Gulf of Trieste, northern Adriatic Sea.

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Common bottlenose dolphins (*T. truncatus)* inhabiting the Gulf of Trieste and adjacent waters of the northern Adriatic Sea have been the focus of a long-term study since 2002, primarily through boat-based and land-based surveys, focal follows and photo-identification. This population is relatively well studied, but its nocturnal occurrence and behavior patterns remain poorly understood. Passive acoustic monitoring methods help us to better understand such patterns when visual observations are limited by weather, daylight or other conditions. Between January 2015 and March 2016 we used a passive acoustic instrument C-POD to monitor dolphin occurrence at a fish farm in Piran Bay, Slovenia, to better understand potential interactions between dolphins and local aquaculture. The KERNO classification algorithm within the CPOD.exe software was used to classify dolphin click trains. Only high and moderate quality click trains were used for further analyses. We used negative binomial generalised additive models (GAMs) in software R to study the relationship between dolphin occurrence and potential covariates such as water temperature, noise, angle of the C-POD, hour of day and month. The C-POD recorded for a total of 17216 hours, including 2280 dolphin detection positive minutes (DPM), which represented 4.53% of all recorded minutes. Most dolphin detections occurred in September 2015 with a total of 648 DPM, while the lowest detection rate was in October with no DPM. The final GAM model included water temperature, hour and angle, and explained 18.8% of deviance, with water temperature being the most important explanatory variable of dolphin presence. Since the area is also a popular summer destination, the follow-up of this study will also help us to better

understand the impacts of tourism and maritime traffic on dolphins in this area.

Growing up with the cool kids – How population density, age and body condition relate to behavior of young Galapagos sea lions.

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Living in the demanding waters near the equator, Galápagos sea lions (*Zalophus wollebaeki*) are increasingly confronted with additional challenging factors ranging from overfishing to climate change. To help improve conservation efforts, it is crucial to understand how this endangered marine predator is affected by such changes. Since an individual's behavior is a key component of the immediate response to an environment, studying its diversity, mechanisms and consequences in a population is a prerequisite for a better understanding of a species and its ecology. However, due to methodological constrains of fieldwork, most behavioral research is done under artificial conditions, making it difficult to transfer those findings to natural circumstances. The island tameness of Galápagos sea lions provides the opportunity to gather high-resolution behavioral observations of individuals in combination with physiological measurements and standardized behavioral response-tests. We present the first results of the most in-depth study of natural behavior of Galápagos sea lions, following a three-step approach. We developed (1) a detailed ethogram representing the most comprehensive description of behavior for this species. With help of this ethogram, we (2) studied and found an influence of population density, habitat, age and body condition, on the behavior of twenty pups, which paved the way to (3) look at consistent individual differences in the behavior of those pups, correlating their natural behavior with their behavioral responses toward different personality tests. This project is part of a long-term study, which gives the opportunity to follow individuals for years, observe the ontogeny of their behavior into adulthood, and see the consequences of early experiences on later life success. This study, thereby, will extend our knowledge on the development and adaptation of behavior in general, but will also provide information to better understand and hopefully protect this species of iconic status.

Assessing the recovery of an Antarctic predator from historical exploitation.

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The recovery of whale populations from centuries of exploitation will likely have management and ecological implications due to greater exposure to anthropogenic threats and increasing competition with human and other predators for prey resources. A Bayesian population dynamics model that integrates catch data, estimates of absolute and relative abundance, and information on genetics and biology is used to assess the recovery of western South Atlantic (WSA) humpback whales (*Megaptera novaeangliae*). Modeling scenarios are used to evaluate the sensitivity of model outputs resulting from the use of different data, different model assumptions, uncertainty in the allocation of catches, and whales struck and lost. Model-averaged estimates of quantities of interest indicate that a long period of exploitation in the 19th and early 20th centuries drove WSA humpback whales to the brink of extinction. They declined from an estimated 27,200 individuals in 1830 (95% probability interval [PI] = 22,800-33,600) to only 450 whales (95%PI = 200-1,400) in the mid-1950s. Protection in the 1960s led to a strong recovery and the current population (24,900 individuals, 95% PI = 22,400-27,000) is estimated to be at 93% of its pre-exploitation size (95% PI = 73-100%). Results show that previous assessment models that ignored pre-modern whaling catches and whales struck but lost at sea resulted in positive bias in estimates of recent status and time to recover to pre-exploitation abundance. The current WSA humpback whale population likely annually removes 1.52-2.68 million tons of their primary prey, Antarctic krill (*Euphausia superba*), and has the potential to modify the community structure in their feeding grounds. Continued monitoring is needed to understand how these whales will interact with krill and other krill-dependent predators, and how they will respond to modern threats and to climate-driven changes to their habitats.

Do environmental variables affect harbor and gray seal haul out frequency at an offshore haul out site, Mount Desert Rock Marine Research

Station?
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This work summarizes the trends in harbor seal and gray seal abundance at an offshore haul out site, studying the effect of environmental conditions on daily seal counts for the summers of 2016 through 2019. Allied Whale's field station at Mount Desert Rock (MDR), a small rock formation 25 miles offshore, is a regular haul out site for gray seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) in the northern Gulf of Maine. Seal haul out ledges are used throughout the year at all hours, but the number of seals using these ledges increase significantly during low tides. Daily seal counts across the island of MDR have been conducted regularly for decades at both high and low tides. On average, harbor seal counts are doubled in frequency than gray seal counts; high tide seal counts are markedly dominated by harbor seals with an average of 11 times the number of gray seals hauled out. Environmental variables during summer seasons 2016 - 2019 measured and analyzed include nearshore water temperature and air temperature measured regularly with a HOBO TidbiT data logger, cloud cover, and weather state. The daily seal counts, conducted from June to August, were correlated against regularly collected environmental variables to study the effect of temperature and weather conditions on the number of seals hauling out at MDR. These data are useful for understanding pinniped haul out behavior in the face of environmental variables at an important feeding haul out site in the northern Gulf of Maine.

Sarcocystis neurona Type II and Type VI genotypes associated with fatal polyphasic rhabdomyositis in stranded California sea lions
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Protozoal tissue-encysting parasites (e.g. *Sarcocystis neurona*, *Toxoplasma gondii*) are emerging pathogens in marine mammal populations, including several listed or endangered species. Despite their significance, the extent to which these parasites contribute to pathology in these populations is not fully characterized. As part of a continuous surveillance effort, 165 marine mammals (representing three otariid species, two phocid species and four odontocete species) stranding between February 2016 and July 2017 along the California coastline were necropsied and assessed for protozoal infection using PCR-DNA sequencing. A high prevalence (n=61, 37.0%) of protozoal infection was detected, including *Toxoplasma gondii* (n=41), *Neospora caninum* (n=2), and *Sarcocystis neurona* (n=20), with four coinfected animals and two animals infected with novel protozoan species. In most marine mammals, fatal protozoal infection results from meningoencephalitis. Bivariate analyses between cause of death, sample population characteristics (i.e. sex and age), and protozoal infection status incorporating all 165 necropsied animals found only *S. neurona* infection associated with fatal polyphasic rhabdomyositis in the absence of neurologic disease as significant (p=0.007). When parsed using California Sea Lions (CSL) only, the association remained significant (p=0.01), but with a lower statistical power (alpha = 0.05). *S. neurona* infected CSL dying of myositis-related causes were predominantly subadult or younger animals. No other associations were found. Multilocus genotyping of *S. neurona* infected animals using high resolution surface antigen and microsatellite biomarkers revealed a preponderance of Type II and Type VI strains, two strains commonly found associated with causing neurologic disease in circulating marine mammal populations along the Eastern Pacific coast of the United States. This study confirms a significant association between *S. neurona* strains and a novel myositis in CSLs. What remains unknown is why this novel disease presentation has emerged only in one host species.

River bank habitat assessment of the Yangtze finless porpoise in main stem of the middle and lower reaches of Yangtze River
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Habitat quality can directly affect population abundance and distribution of the Yangtze finless porpoise; however, current habitat status for the Yangtze finless porpoise in the Yangtze River remains unclear. In this study we investigated habitat status of both south and north banks of the main stem of the Yangtze River by taking high-resolution digital photos systematically during the 2017 Yangtze Freshwater Dolphin Expedition from November 10th to December 17th, 2017. The survey area covers the entire middle and lower reaches of the Yangtze River from Yichang to Shanghai (1669km in length) and a total of 794 photo samples were collected. In the meanwhile, we recorded 318 sightings with 631 individuals of the Yangtze finless porpoise. We conducted a Chi-squared goodness of fit test showing that proportions of observed frequency are significantly higher than the expected frequency in natural river banks (χ^2=69.81, P<0.001). Whereas the result is opposite in the semi-natural and solidified river banks (χ^2=39.26, P<0.001; χ^2=12.15, P<0.001), which indicating the natural river banks were the preferred habitat of the Yangtze finless porpoise. The results also showed that the length of the semi-natural river and solidified banks accounted for 45.47% of the total length of the river bank and their patches intermingled with the patches of the natural river banks. These results suggested that the natural habitat preferred by the Yangtze finless porpoise was severely degraded and highly fragmented, which could be the primary reason leading to the fragmented distribution pattern of this species in the Yangtze River. Our study suggested that habitat degradation and fragmentation pose a significant threat to the survival of the Yangtze finless porpoise. Future conservation research and practice should focus on habitat restoration of the solidified river banks to reestablish and enhance habitat connectivity.

Dentine stable isotopes reveal weaning age and variation in diet among narwhals (Monodon monoceros) harvested 30 years apart.

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Changing food webs in the Arctic will alter prey dynamics and may lead to diet shifts for predators. This can have energetic consequences for individuals and impact nursing duration, which may be prolonged or shortened depending on prey availability. Monitoring diet and nursing is difficult for Arctic marine mammals; however, it is made possible by employing stable isotope analysis (SIA) of dentine in teeth/tusks. Dentine is metabolically inert and accumulates as annual growth layer groups (GLGs) in marine mammal teeth. SIA of sequential dentine GLGs can provide a lifetime record of individual diet and be applied to infer weaning, the time at which nursing comes to an end and calves switch from milk to solid food. We used SIA of dentine from narwhal embedded tusks to investigate whether narwhal weaning, and post-weaning diet differ between sexes and among individuals over a 30-year time period. Embedded tusks from both sexes were collected near Pond Inlet, Nunavut, from 1982 – 1983 (n=12) and 2015 – 2017 (n=14). Weaning age was estimated through a ~ 1‰ decline in $d^{15}N$ over the first few GLGs. Ontogenetic $d^{13}C$ and $d^{15}N$ profiles and an isotopic niche breadth were constructed for each individual to compare feeding habits among narwhals. Fifteen narwhals sampled weaned by age one, while 11 were nursed into their second and up-to fourth year. Weaning age did not differ between sexes or time periods. Post-weaning, narwhals showed varied degrees of dietary overlap between individuals ranging from 0 – 100%, suggesting diverged feeding strategies were adopted by different whales. Variation in isotopic niche breadths among narwhals indicates some whales have a more specialized diet than others. This study provides insight on how narwhals have been impacted by climate-induced resource shifts, and the potential for narwhals to adapt to food web changes in the future.

Inbreeding and inbreeding avoidance in Yangtze finless porpoise

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Recent population survey indicates that the Tian'e-Zhou *ex situ* conserved Yangtze Finless Porpoise (YFP, *Neophocaena asiaeorientalis asiaeorientalis*) population has been increasing stably and fast in the past few years. This breeding population now consists of more than sixty individuals that the sex ratio is very close to 1:1. The reproduction occurred within limited number of founders and genes circulated in the relatively closed exchanging pool leads to serious inbreeding risks in such a booming population. Therefore the potential level of inbreeding and the possible existing inbreeding avoidance mechanism are attempting for us to investigate which never been studied in this species. This research

documented the development of a 60-individual pedigree of YFP population. Their relationships were determined by genetic information over four generations in 2015. Mating system and inbreeding rate were studied by parentage-based pedigree analyses using 21 microsatellite loci and a 597 bp segment of the mitochondrial DNA control region. This study identified 37 potential mother-offspring pairs and 38 potential father-offspring pairs (including 32 potential parents-offspring pairs). Among them five maternal multigenerational families were uncovered. It is the largest and most complicated pedigrees ever constructed. The result indicate that the YFP exhibits matrilineal society that characterized with polygamous and male-biased dispersal that is a common way to avoid inbreeding. One case of inbreeding between father and daughter was uncovered and one case of inbreeding happened between halfblooded sibs who share the same father but different mothers. Conversely, we find no case of inbreeding between relatives in the same matrilineal family. This suggests a kind of active inbreeding avoidance strategy also exist to promote avoidance of inbreeding. The ability to recognize maternal relatives, primarily by individual or group-specific vocalizations, may play an important role in inbreeding avoidance.

Tracking the Yangtze finless porpoise by using the non-invasive radio system

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Using tags to track animals can provide insight into their ecology ranging from insects to whales. However, we face great challenge of deploying tracking devices on small toothed whales without the dorsal fin. In June 2018, we tracked two Yangtze finless porpoise in the Poyang Lake by using a newly developed tracking vest to protect tracking tags. The vest has a great elasticity with dense holes to ensure water permeability. In addition, keels were designed to prevent the vest from curling together. Radio tags (designed to lasted for 2 months, 120g, 110*52*12 mm) were made with a transmit frequency of 433 MHz. The receiving base stations were deployed on navigation buoys to collect and transmit real time locations automatically. One of the two tags failed to work immediately after it was released. Observations and photos showed that after released, the two animals stayed together and had integrated into the surrounding porpoise groups. A total of 22,940 minutes tracking with 100,980 surface behaviors were recorded. After released, they moved to a bunker (~2km in length) 10km downstream and stayed there for two days. Then, with the water level rising, they moved to the bunker (~5km in length) 30km downstream and stayed there for 12 days. These records indicate that the porpoise may stay in the bunkers for a long time during the dry seasons, and the fluctuation of the water level is one of the factors driving them to move. After the signal disappeared, we searched for a month in the surrounding waters and found no porpoise or corpse wearing a vest which implies that the vests have been safely detached. This is the first successful long-term tracking of the movements of the Yangtze finless porpoise and the tracking vest provides a new non-invasive way to safely track small toothed whales.

The underwater noise impact on the Yangtze Finless Porpoises (Neophocaena asiaeorientalis asiaeorientalis) in the downstream of Nanjing of Yangtze River of China

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The research on how the underwater noise influences the endemic and endangered Yangtze Finless Porpoises (YFP) inhabiting the lower reaches of Yangtze River is extremely limited and indispensable for their conservation. Passive acoustic monitoring in three different points spreading in the lower Nanjing range of the Yangtze River of China was continuously conducted for 14 days in July 2018. The non-parametric test and correlation analysis were utilized to analyze the data. The number of click trains, acoustic witness, and witness duration show uncorrelation to root-mean-square sound pressure level (SPL*rm*) and peak sound pressure level (SPL*p-p*), while they are significantly related to the variance of SPL*p-p*. This indicates that the appearance of porpoises and the duration of their stay probably not be influenced by the mean level of noise, however, they are affected more by the fluctuation of peak level of the noise. Additionally, there is a significant pertinence between the number of buzzes (related to predation) and the variance of SPL*p-p*. It reveals that the stronger the peak level of the noise fluctuates is, the less the porpoises prey. It is claimed that sound environment with drastic undulation of peak level is disadvantageous to the porpoises' predation. Furthermore, the limit of lower frequency of porpoises signals has significant positive correlation with the increase of SPL*rm* and SPL*p-p*, since the SPL*rm* decreases when the noise frequency goes up based on the 1/3 octave band

sound pressure level analysis. And porpoises are easier to discriminate their echolocation signals from higher frequency noise with lower SPL*rm*. To compromise this higher noise level, the lifting of lower limit of signal frequency might cost porpoises more energy. The results inspire us to consider both the fluctuation of peak level of noise and the average noise level when determine the conservation strategy for YFP.

Let sleeping dolphins swim: Characterizing sleep behaviour of wild Indo-Pacific bottlenose dolphins (Tursiops aduncus) in the Northern Red Sea, Egypt.

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Undoubtedly, sleep is an essential part of life. While all animal studied to date sleep, cetaceans are among the few that exhibit unihemispherical sleep, where only half of the brain displays typical signs of sleeping due to their continual need for breathing and movement. Most sleeping studies in cetaceans so far have been conducted in captivity, but suggest certain behaviours such as circular swimming are associated with sleeping in cetaceans. However, little is known about sleep behaviours in the wild. Since 2012 *ad libitum* boat-based and underwater SCUBA-based behavioural data (videos/photos) of the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) have been collected off Hurghada, Egypt. This record provides a unique opportunity to define and study behavioural characteristics of sleeping in the wild, defined here as a period where an individual has at least one eye closed. These videos provide confirmed observations of tight group movement during sleeping in wild cetaceans, and reveal that sleeping is further influenced by social factors and habitat selection, such as reef sites. Hence, this study provides a greater understanding of factors that affect sleep behaviour in wild Indo-Pacific bottlenose dolphins. Particularly, the high association of sleeping behaviour with reef sites suggests that this habitat type is essential for the resident dolphin population. Such an understanding, in turn, enables an effective management for conservation as particularly the Egyptian Northern Red Sea is facing increased pressure of touristic activities.

Clear movement responses by bottlenose dolphins to whistle playbacks

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Experimentally testing animal communication theories using field playback experiments with free-swimming cetaceans remains notoriously challenging, as animals are seldom in view when exposed to playbacks. To examine responses of wild bottlenose dolphins to signature whistles of familiar and unfamiliar dolphins, we performed 16 whistle playbacks to 13 individual dolphins in the resident Sarasota Bay, Florida, community, while they were wearing digital acoustic tags (DTAGs). We examined whether movement responses were discernible on the tag accelerometers. Each dolphin was exposed to two playbacks, each of which consisted of two whistles separated by 3 seconds of silence. One stimulus was from a dolphin from a geographically separated population (unfamiliar signature) and the other was from a highly associated dolphin (familiar signature). Clear motion responses were evident in every case, with varying degrees of intensity and duration. Two young males showed short-lived responses (less than 10 seconds), whereas three mothers with dependent calves showed stronger and more prolonged responses (exceeding 1 minute). Two adult males traveling together also showed strong and prolonged (about 1 minute) reactions. Surprisingly, whether the stimulus was a signature whistle of a familiar or unfamiliar dolphin did not appear to affect the magnitude or duration of the response. Although more data are needed, especially from young animals, our preliminary results indicate that older (greater than 4 years) dolphins show stronger responses to whistle playbacks than younger (independent) animals. Further research is needed to determine whether and to what degree social context, behavioral state

and playback design (e.g., stimulus features, post-tagging effects) may have influenced these responses.

Structural and biophysical characterization of the Cetacean morbillivirus haemagglutinin.

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Cetacean morbillivirus (CeMV) is an enveloped, non-segmented, negative-stranded RNA virus that infects marine mammals and spreads between species, causing lethal disease outbreaks worldwide. Among the eight proteins encoded by the CeMV genome, the haemagglutinin (H) is responsible for the virus binding to cellular receptors, thereby enabling its entry into the host cell. As a determinant of virulence and pathogenesis, CeMV H represents an attractive target for antiviral and diagnostic research. Yet the elucidation of the molecular mechanisms underlying its role in infection and inter-species transmission has been hampered so far due to the unavailability of a recombinant version of the protein. Here we present the cloning, expression and purification of the recombinant CeMV H ectodomain in a heterologous system, providing a molecular view of its structural organization by means of biochemical (sodium dodecyl sulphate - polyacrylamide gel electrophoresis (SDS-PAGE), Western blot (WB) – periodic acid Schiff (PAS), blue native (BN)-PAGE, liquid chromatography mass spectrometry (LC-MS)), biophysical techniques (size exclusion chromatography - multiangle light scattering (SEC-MALS), miniaturized differential scanning fluorimetry (nano-DSF)) and negative stain three-dimensional electron microscopy (3D-EM) single particle analysis. Results show that the recombinant CeMV H ectodomain is natively glycosylated, globularly folded and thermally stable. Moreover, CeMV H exists in solution in the oligomeric states of dimers and multiple of dimers. Furthermore, the low-resolution density map obtained by 3D-EM represents the first experimental model for the delineation of the CeMV H molecular architecture. Paving the way for future investigations at atomic level, the structural insights here presented serve as a fundamental framework towards an understanding of the CeMV H function.

Scaling the laws of marine mammal detection using thermal imaging

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Marine mammals are under growing pressure as anthropogenic use of the ocean increases. Ship-strikes of large whales and loud underwater sound sources including airguns for marine geophysical prospecting and naval mid-frequency sonar are criticized for their possible negative effects on marine mammals. Competent authorities regularly require the implementation of mitigation measures, including vessel speed reductions or shut-down of acoustic sources if marine mammals are sighted in sensitive areas or in predefined exclusion zones around a vessel. To ensure successful mitigation, reliable at-sea detection of animals is crucial. To date, ship-based marine mammal observers are the most commonly implemented detection method, however thermal (IR) imaging based automatic detection systems have been used in recent years. We evaluated thermal imaging-based automatic whale detection technology for its use across different oceans. During six field experiments between 2014 and 2017 in Australian, US and Canadian waters we assessed the performance of this technology and characterized it with respect to environmental conditions with and without use of an automatic detection algorithm for whale blows. We show that the technology can detect whales in polar, temperate and subtropical ocean regimes over distances of up to several kilometers and in some situations outperforms marine mammal observers in probability of whales detected. We present dual platform performance comparison of real-time marine mammal detections by the thermal imaging system and traditional marine mammal observers. Our results show that thermal imaging technology can be used to assist in providing protection for marine mammals against ship-strike and acoustic impact across the world's oceans and provides a hitherto unique night-time ability to detect whales at the surface.

Results of visual observer aerial surveys for six large whale species in the New York bight

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Abundance, seasonality, and density of large whale species in the New York Bight have not been intensively studied to date. Assessing impacts from potential future development in the NY Offshore Planning Area requires current and comprehensive data on these species. This longitudinal multi-year study is investigating 6 large whale species (North Atlantic right whale, blue, fin, sei, humpback, and sperm whale) by conducting monthly visual aerial surveys. Survey transects run from the south shore of Long Island, NY to beyond the continental shelf break (total survey area of 43,449 km^2). Aerial line-transect methods are being used to allow estimation of density and abundance using distance sampling techniques. Data from the first 2 years have been analyzed. In Year 1 (Y1), 73 sightings were recorded while in Year 2 (Y2) 143 sightings were recorded. Combined density of the 6 whale species in Y2 was 0.00235 individuals/km^2 and total abundance was 102 (CV = 21.11%), representing improved accuracy over Y1 density estimates, which were based on a smaller sample size. Density estimates (individuals/1,000 km^2) were highest for humpback (Y1=0.483; Y2=1.513) and fin (Y1=0.506; Y2=0.658) whales in both years. Sei whales were only seen in Y2 (0.011) and blue whales only in Y1 (0.046). Sighting rates varied seasonally; in both years fin whale sighting rates were highest in spring and humpback whale sighting rates were highest from summer through winter. North Atlantic right whales were seen during 5 months in Y1 in fall, winter, and spring and 3 months in Y2 in winter and spring. Photographs of right whales in Y1 and Y2 were submitted to the New England Aquarium, resulting in the identification of 6 individual right whales, including 2 whales new to the catalogue. Surveys will continue through February of 2020 for a total of 3 years of data collection.

Distribution and resource division of the two coastal dolphins inhabiting the southern Israeli Mediterranean coast

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The southeastern continental shelf of the Levantine Basin was recently announced by IUCN's Marine Mammal Protected Areas Task Force as an Important Marine Mammal Area (https://www.marinemammalhabitat.org/portfolio-item/coastal-shelf-waters-southeast-levantine-sea) on account of both the common bottlenose dolphin (CBD; *Tursiops truncatus*) and the common dolphin (CD; *Delphinus delphis*) inhabiting the area. During the last decade, both species are sighted year round, with CBD maintaining a presence along the entire Israeli coast and CD being confined to its southern portion. In order to establish science-based conservation measures, a thorough understanding of the level of geographical and ecological overlap of the two species off the southern coast is required, together with the degree of distributional overlap with putative anthropogenic threats (e.g. gas industry & fishing) and conservation measures (e.g. marine protected areas). In other areas around the world, the two species' overlap is possible due to different diets, with CBD being mainly a benthonic predator and CD feeding on epipelagic and mesopelagic schooling prey (the latter while upward migrating at night). In Israel, stomach content analysis suggests that both species are exploiting trawlers as a food source, with partial diet overlap. In the case of CD, this may enable presence during seasons when its typical prey is at low supply. This research will deploy technologies aimed at expanding the knowledge about distribution (boat and unmanned aerial surveys), daily habitat utilization (moored passive acoustic recorders coupled with the development of dedicated CBD-CD species-classification software), resource sharing/division (stomach contents and stable isotope analysis) and interaction with trawlers (net-attached underwater cameras). Preliminary mapping results show CD sightings during daylight hours not to extend beyond 10 km from shore and rarely beyond the 50 m isobath. The proposed first stage of the Avtach Marine Protected area (70 km^2) covers roughly 6% of CD's daylight area of occupancy.

Follow the leader or take a vote? Long-finned pilot whales choose democracy for their day-to-day diving decisions.

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Long-finned pilot whales (*Globicephala melas*) are a gregarious, social species of cetacean that live in long-term stable matrilines. Their common name – pilot – refers to assumptions that an individual leads the group, but how they make their day-to-day decisions is still a mystery. Theoretical models predict that most social-living organisms would be expected to use shared consensus decision-making processes, as this leads to greater expected fitness gains at both a group and individual level unless there is significant asymmetry in ecological knowledge among group members. In this study we used drone-collected footage of long-finned pilot whales summering off Cape Breton Island, Nova Scotia, to look at whether group decision-making events, such as deep dives or turns, showed evidence of leadership or shared consensus processes. Preliminary analyses used 239 minutes of aerial video footage of long-finned pilot whales (N=136) from 11 independent groups to look at transitions from a shallow diving pattern to a deeper, longer dive where all whales dove out of sight for periods of over 45 seconds. In these cases, the interval between the 1stand 2nd dive (median 0.7s) was similar to that between subsequent pairs of dives: 0.9s between the 2ndand 3rd, 1.1s between the 3rdand 4th, 0.6s between the 4thand 5th, and so forth. This suggests that pilot whale dive decisions are generally consensual. However, in two of the groups the first individual to dive had a substantial lead over subsequent dives (3.0s and 14.6s respectively), which may indicate attempted leadership. Determining how long-finned pilot whales achieve consensus is important for learning more about their within-group behavioural structure and dynamics, which are poorly understood.