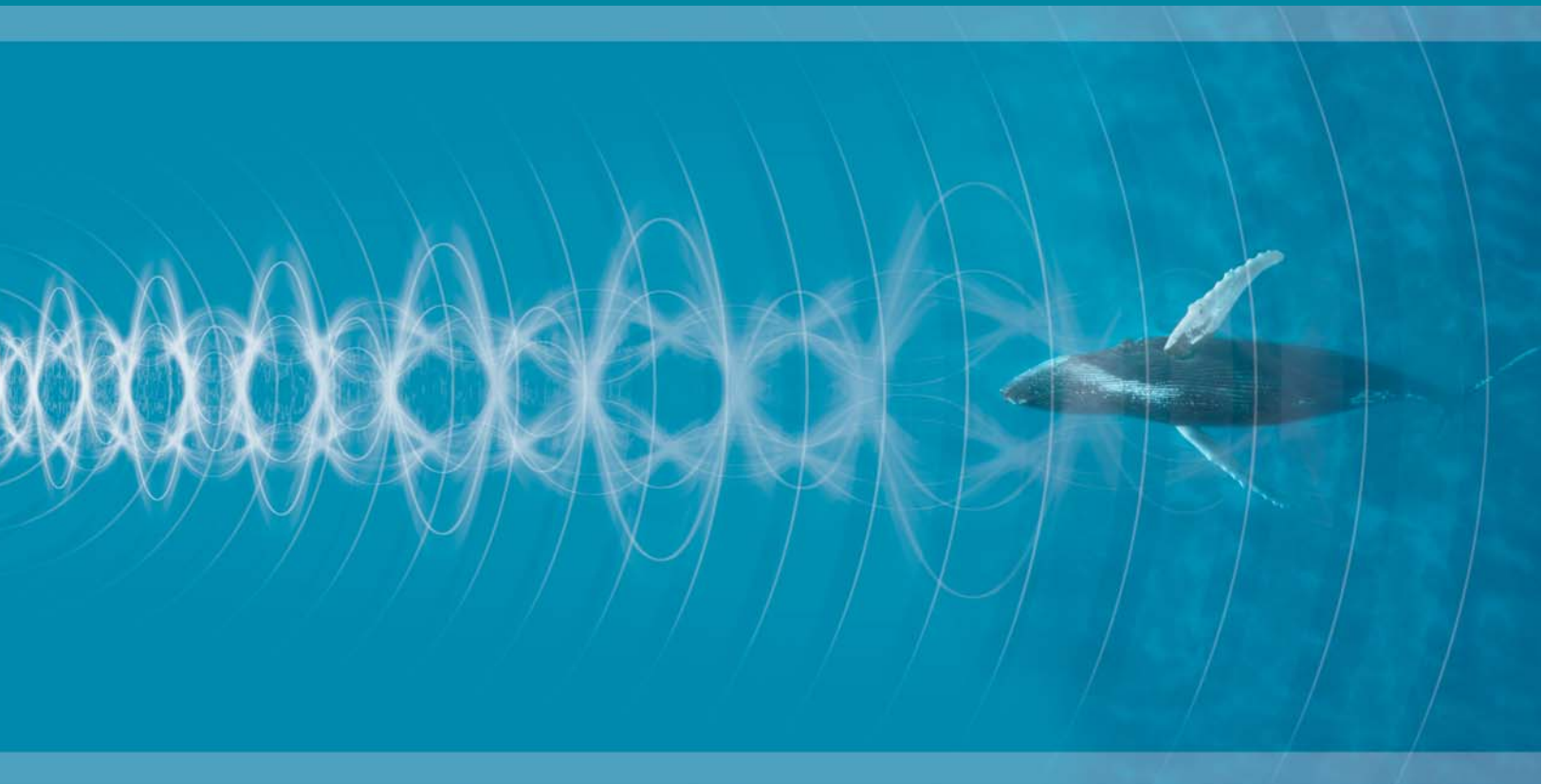


Ocean Noise: Turn it down

A report on ocean noise pollution



“Noise: a sound, especially one that is loud, unpleasant, or disturbing.”

Oxford English Dictionary

CD contents include:

- IFAW/NRDC video on ocean noise pollution narrated by Pierce Brosnan - 4 mins 47 secs
- PDF of this report

Warning: Flashing images appear on the interface screen and in video one

Ocean Noise: Turn it down

A report on ocean noise pollution published by IFAW, June 2008

About IFAW

The International Fund for Animal Welfare is one of the world's leading international animal welfare organisations. IFAW works throughout the world to improve the welfare of wild and domestic animals by protecting wildlife habitats, reducing commercial exploitation and helping animals in distress. We seek to motivate the public to prevent cruelty to animals and to promote animal welfare and conservation policies that advance the well-being of both animals and people.

IFAW has more than 1.5 million supporters worldwide and is staffed by more than 200 experienced campaigners, educators, internationally acclaimed scientists and legal and communications experts. IFAW has offices in Australia, Brussels (EU), Canada, China, France, Germany, India, Japan, Kenya, Mexico, Netherlands, Russia, South Africa, UAE, UK and the US.

For more information about IFAW and its campaigns visit www.ifaw.org

Acknowledgements

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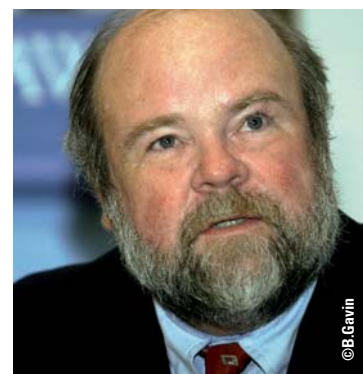
Foreword

The great whales and other marine species that share our ocean planet swim in a sea of troubles. Threats to these magnificent creatures and their underwater habitats seem to proliferate daily. Industrial chemicals, heavy metals and fertilisers, inappropriate coastal development, a rising tide of solid waste, entanglement in outmoded fishing gear, collisions with high-speed vessels, resurgent commercial whaling in the 21st Century and now the massive threat of climate change all threaten their survival. On top of these comes a new, emerging threat, as insidious as it is invisible: ocean noise pollution.

Today humankind is unleashing an acoustic onslaught on the seas. The collective cacophony of millions of noisy ships and boats, the shattering blasts of airguns used in seismic surveys, the deafening din from unrestricted use of high intensity naval sonar and other man-made sounds have begun to silence the natural songs of the sea.

For creatures that depend on their sense of sound to survive this is a severe threat. Unbridled noise pollution is drowning out the calls of whales and other marine mammals with life-threatening consequences for finding food, mating, nurturing young, navigating and communicating across their vast watery realm. Ocean noise pollution is already driving some marine mammals from their breeding and feeding grounds. And while we have much more left to learn, leading marine scientists warn that in addition to losing their hearing from the worst of our largely uncontrolled ocean noise pollution, some marine mammals are already being killed by it.

In a sense, thoughtful policy makers considering this complex issue face the same challenge as the marine mammals IFAW is working to protect: how to separate important sounds and signals from the ambient background noise. This new IFAW report and the practical, science-based policy recommendations it contains provide a clarion call for humanity to turn down the volume. While there is uncertainty about the scale of the harm ocean noise pollution is already causing, it is time for the international community - for governments, international bodies, industry and individuals - to work together to take precautionary action now. Without such collective action the relentless increase in ocean noise pollution may soon threaten marine mammals at population levels. What a terrible irony it would be if the ultimate effects of this 'invisible pollution' became obvious only once it was too late.



Fred O'Regan
President and Chief Executive Officer
International Fund for Animal Welfare

A handwritten signature in black ink that reads 'Fred O'Regan'.

Summary: Farewell to the Silent World

In 1956 legendary marine explorer Jacques Cousteau described the oceans as 'The Silent World' in his film documentary of that name. This description was more romantic than factual: the ocean depths have always been alive with sound, from the breaking of waves to the voices of marine animals beyond count. Today, however, Cousteau's silent world is noisier than it has ever been before. In recent decades undersea noise from human activities has increased dramatically. This increase is set to continue and, unless tackled, poses a potentially major threat to marine animals of many kinds worldwide.

Commercial shipping, seismic exploration, sonar technology, marine construction, dredging and seabed drilling have all benefited humanity. But collectively they have now raised background ocean noise to potentially threatening levels. Shipping is the biggest single contributor, through its propeller and engine noise. Between 1965 and 2003 the world's commercial fleet doubled in size. According to one study ship noise pollution in the Pacific has doubled every decade for the past 40 years.¹ This alarming trend is likely to accelerate: the fleet is forecast to at least double again by 2025.

For people, even relatively low level noise can cause psychological and physical stress, adversely affecting blood pressure, heart rate and cardiac output. But people can usually move away from noise - for ocean creatures escape is often impossible. Sound travels nearly five times faster in water than in air and can invade tens of thousands of square kilometres in seconds.

Moreover, marine animals have developed sensitive hearing and complex sound-making repertoires, such as echolocation, with which to navigate, communicate, detect mates or rivals, maintain group cohesion and find food in their largely dark environment. Cetaceans - whales, dolphins and porpoises - have particularly sensitive hearing and their reliance on sound is almost total.

Man-made noise has begun to interfere with and even drown out these crucial sound-based systems. The mighty blue whale once communicated across entire oceans, but no longer: noise pollution has reduced its acoustic range by nine-tenths.² Such effects must inevitably pose serious questions about these animals' continued ability to find mates and food in the vastness of the oceans.

Ocean noise pollution is also being linked with behavioural changes that have been seen in marine animals around the world, including the abandonment of preferred habitat, alterations in surfacing and diving patterns and in the types, timing and volume of calls. At least some cetaceans are known to have changed their calls as they struggle to make themselves heard. Ocean noise pollution may also be behind incidences in which marine animals have abandoned vital activities, such as feeding. It may even be causing fatalities: high intensity military sonar is implicated in the deaths of beaked whales and mass strandings of cetaceans around the world.

So the Silent World is now a noisy place indeed and that noise is increasing. Neither the extent of the detrimental effects of this insidious form of pollution nor its consequences for marine animals are yet clear. Unless the international community takes action to tackle ocean noise pollution, however, we are likely to discover only too late the damage we are causing.

In recent decades undersea noise from human activities has increased dramatically. This increase is set to continue and, unless tackled, poses a potentially major threat to marine animals of many kinds worldwide.

¹ McDonald et al., 2006

² Based on an increase in ambient noise levels of 15dB (McDonald et al., 2006) and a typical 15logR loss, where R is the distance between the two whales.

The blue whale once communicated with others of its species across entire oceans. Today, the distance over which these whales can hear each other has been reduced by around nine-tenths because of increased noise levels.



Where sound is king

Sunlight fades rapidly beneath the surface of the oceans. Thirty metres down most colours have been absorbed, by 200 metres light is all but gone. Below 1,000 metres the ocean is a place of complete darkness. In the underwater world sound is king.

Marine mammals use sound to navigate and to detect predators and prey. It is essential for communication in order to attract mates, announce location and territory, to establish dominance and maintain group cohesion and social interaction. The toothed whales or odontocetes - which include dolphins, porpoises, beaked whales, sperm whales and killer whales - use echolocation to obtain environmental information such as water depth, the location of food and the distance of objects.

This means that marine mammals need to make and use sound continually. The sounds they make vary greatly, however. Toothed whales make a variety of clicks and whistles. Baleen whales emit tonal moans but also knocks, pulses, thumps and trumpet-like sounds. Humpback and bowhead whales famously make extended "songs" in their breeding grounds. Meanwhile the pinnipeds - seals, sea lions and walruses - also make a wide range of sounds. Marine mammals' calls occupy a huge variety of frequencies ranging from the high pitched 120-150 kHz echolocation clicks of the harbour porpoise to the ultra low frequency 10-15 second booms of the blue whale, which can be lower than 20 Hz and travel many hundreds of kilometres. Both these animals' calls are beyond the range of human hearing but those of many of the world's other marine mammal species are audible to us.

To detect these sounds over vast ocean areas marine mammals have developed acute hearing, which is attuned to broader frequency ranges than are common in land mammals.³ Darlene R. Ketten, a senior scientist at Woods Hole Oceanographic Institution, maintains: "Hearing is arguably their premier sensory system - it is obvious from their level of ear and neural auditory centre development alone. Dolphins and whales devote three-fold more neurons to hearing than any other animal. The temporal lobes, which control higher auditory processing, dominate their brain and they may have more complex auditory and signal processing capabilities than most mammals."

While it appears that the mechanisms of hearing damage are similar in both land and marine mammals, currently there is relatively little information on how the latter respond to intense sound. Audiograms - records of hearing ability that can be used to measure hearing loss - exist only for about 20 marine mammal species, all of which are toothed whales and pinnipeds that were tested in captivity.⁴ This means that there is no direct behavioural or physiological hearing data for almost 80 per cent of marine mammals.

Marine mammals use sound to navigate and to detect predators and prey. It is essential for communication in order to attract mates, announce location and territory, to establish dominance and maintain group cohesion and social interaction.

“ There is growing concern that noise proliferation poses a significant threat to the survival of marine mammals, fish and other marine species... Flooding their world with intense sound interferes with [their] activities with potential serious consequences. ”

UN Secretary-General
Report on Oceans and the Law of the Sea, 2007



Man-made ocean noise: the invisible pollution

Commercial shipping

Since their introduction in the 19th Century propeller-driven ships have become the single most dominant source of man-made low frequency noise throughout much of the world's oceans. The noise is caused primarily by 'propeller cavitation', which occurs when the low pressure generated by the propeller causes thousands of tiny bubbles to form in the water. The sound these bubbles make when they burst is the major source of noise from boats under power. Shipping noise interacts with sounds made by many species of whale across a broad range of frequencies and particularly with the 20-500 Hz vocalisation range of large baleen whales (see Figure 2, page 19). The noise created by shipping is immense. Commercial shipping generates sound pressure levels that range between 150 and 195 dB at source.⁵ Moreover, these sounds are continuous.

With more than 90 per cent of the world's commerce reportedly dependent on ocean transport it is no surprise that the commercial shipping fleet has been growing fast. The gross tonnage of commercial vessels nearly quadrupled from 160 million GT in 1965 to 605 million GT in 2003, with a similar increase in propulsion power.⁶ Today the world's merchant fleet of vessels of 100 GT and above numbers 97,000⁷, including some 11,000 tankers. The largest of these tankers displaces over half a million tonnes. By 2025 the amount of cargo shipped around the world is forecast by shipping analysts to double or even triple.

With a trend towards ever larger, faster and more powerful ships the commercial fleet of tomorrow is likely to generate even more noise. The effects of global warming are also opening up new areas of the world's oceans to commercial shipping: Arctic ice shrinkage may soon enable ships to sail regularly over the top of the world for the first time.

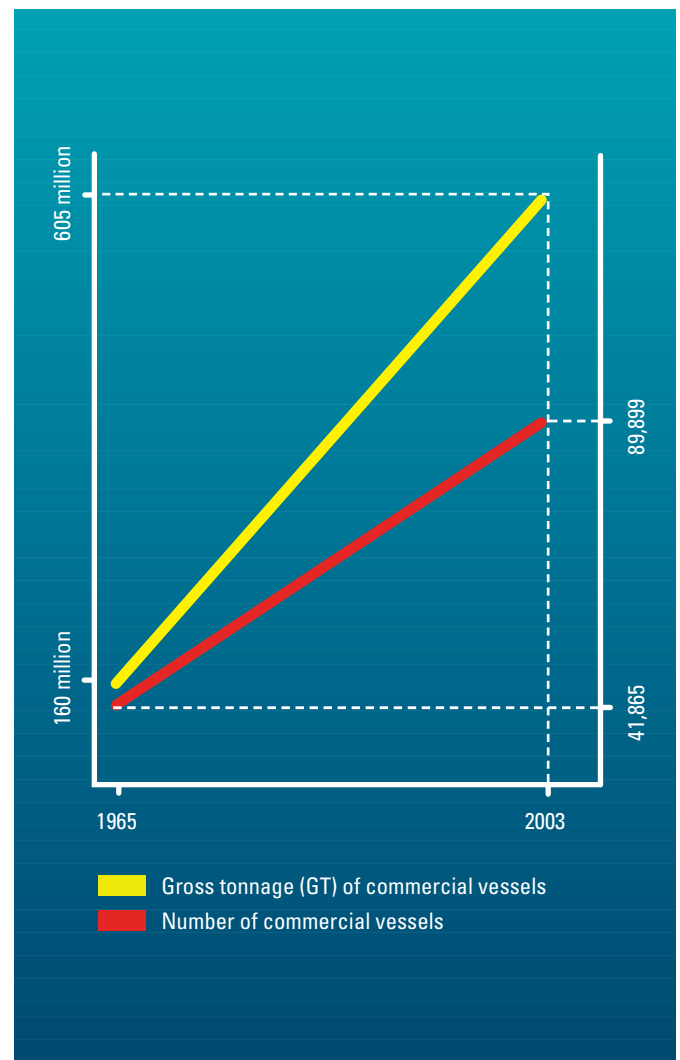


Figure 1: Increase in commercial shipping

By 2025 the amount of cargo shipped around the world is forecast by shipping analysts to double or even triple.

⁵ Hildebrand, 2004 reports that peak spectral densities for individual ships range from 195 dB re $\mu\text{Pa}^2/\text{Hz}$ @ 1 m for fast moving supertankers, to 140 dB re $\mu\text{Pa}^2/\text{Hz}$ @ 1 m for small fishing vessels.

⁶ Ross, D.G., 1993

⁷ Lloyds Register, Merchant Fleets of the World, 2007. 50,000 cargo carrying vessels and 47,000 miscellaneous vessels including tugs, dredgers and fishing boats.

“ ...given the wide-ranging geographical occurrence of shipping, the fact that the low frequency sounds from ships travel great distances, and its ever increasing prevalence, the potential problems for acoustically-oriented marine animals from noise generated by shipping is of increasing concern. ”

The United States,
Submission to the International Maritime Organization's (IMO)
Marine Environment Protection Committee, 2008



Airguns

Seismic surveys are another major source of man-made ocean noise. These are used extensively by the oil and gas industries and also by scientists to study the geology of the sea floor and the Earth's crust. Sound is produced typically by arrays of 12-48 airguns, which vent pressurised air into the water as they are towed by survey vessels. A single survey will often involve multiple passes by the array. The sound travels down through the water column, penetrates the sea floor and rebounds to the surface where it is analysed.

The sounds generated by these surveys are colossal, peaking momentarily at up to 259 dB at source.⁸ Moreover, they are repeated approximately every 10 seconds for weeks or months at a time. Not surprisingly, marine mammals have been recorded as fleeing from seismic survey sites. One study showed that airgun activity contributes significantly to ocean noise levels: seismic sounds propagated deep into the Atlantic were detected more than 3,000 km from their sources.⁹ Worldwide the oil and gas industries operate 90 seismic survey ships of which about a quarter are in use on any given day.¹⁰ Additionally, about 80 more ships are capable of conducting seismic surveys for other purposes, such as oceanographic research.¹¹ Inevitably, as demand for energy increases seismic exploration by oil and gas industries is set to grow.

Sonar

At mid and high frequencies the main sources of ocean noise pollution are naval, commercial, fishery and recreational sonar. The world's navies continue to develop and test low frequency active sonar (LFA) aimed at detecting and tracking submarines over long distances. Mid-frequency tactical anti-submarine warfare sonar (ASW) is used to search for submarines over shorter but still considerable distances. There are some 300 such systems in active use worldwide.¹² Naval sonar can create sound pressure levels of more than 235 dB.¹³ Another major concern is sonar used on fishery vessels. This can generate as much as 210 dB. Meanwhile recreational sonar is in use on millions of small boats around the world.

Other sources

Ocean noise pollution is also exacerbated by drilling, construction, off-shore oil and gas production rigs, underwater explosions to test ship strength and acoustic deterrent and harassment devices. The cumulative effects of these multiple sources of ocean noise pollution on marine mammals are unknown.

There has been limited scientific work to establish exactly how much man-made ocean noise has increased in recent times. But what evidence there is gives cause for concern. One study indicates that levels of man-made noise have doubled in each of the past four decades. The study in question, at a site in the Pacific off the southern California coast, found a low frequency noise increase totalling 10-12 dB over those decades.¹⁴

One study showed that airgun activity contributes significantly to ocean noise levels: seismic sounds propagated deep into the Atlantic were detected more than 3,000 km from their sources.

8 Hildebrand, 2004 reports up to 259 dB re $\mu\text{Pa}^2/\text{Hz}$ @ 1 m

9 Nieuirkirk et al., 2004

10 Marine Mammal Commission, 2007

11 ibid


12 ibid

13 Hildebrand, 2004 reports 235 dB re $\mu\text{Pa}^2/\text{Hz}$ @ 1 m

14 McDonald et al., 2006

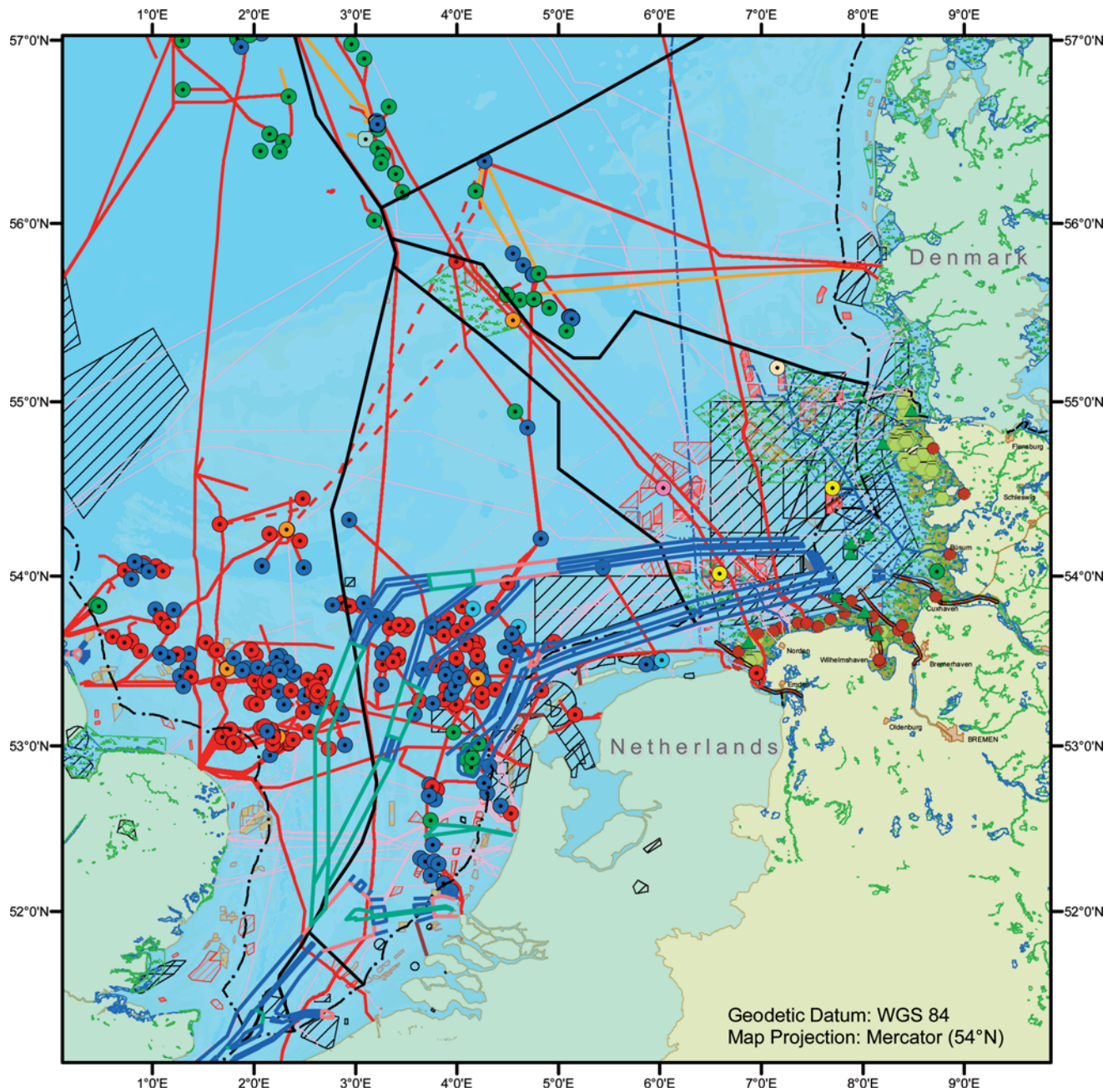
“ We do not yet know what the cumulative effects of all the sources of ocean noise pollution are having or are likely to have on marine animals. But we do know that these animals are already under threat from other human pressures including chemical pollution, climate change, whaling, by-catch and ship strikes. Man-made noise could well interact with and make these pressures even worse, with detrimental consequences for marine animals. ”

Dr Ralf P. Sonntag,
Marine biologist and Director,
IFAW Germany



Humpback whale entangled in lobster traps and their connecting ropes and anchors.

Examples of ocean noise pollution sources in the North Sea



- | | |
|---|---|
| <p>Maritime Features</p> <ul style="list-style-type: none"> — Traffic separation zone — Deep water route — Precautionary area — Inshore traffic zone — Shipping lane (recommended) — Shipping lane (not classified) <p>Boundaries</p> <ul style="list-style-type: none"> — Continental shelf/EEZ · — Territorial waters/12 nm zone — International boundary ▨ Restricted area ▨ Anchoring area <p>Platforms</p> <ul style="list-style-type: none"> ● Unclassified (in use) ● Unclassified (approved) ● Unclassified (out of use) ● Measurement platform (in use) ● Measurement platform (planned) ● Measurement platform (approved) ● Petroleum platform (out of use) ● Petroleum platform (in use) ● Compression platform (in use) ● Compression platform (out of use) ● Natural gas platform (in use) <p>Pipelines</p> <ul style="list-style-type: none"> — Natural gas (in use) — Natural gas (planned) — Hydrocarbons (in use) | <p>Data cables</p> <ul style="list-style-type: none"> — In service — Planned — Out of service — Unknown <p>High voltage cables</p> <ul style="list-style-type: none"> — In service — Approved — Planned <p>Offshore Windfarms</p> <ul style="list-style-type: none"> ■ In use ■ Approved ■ Planned <p>Sediment extraction</p> <ul style="list-style-type: none"> ▨ Project approval procedure ▨ In use ▨ Planned <p>Dumping grounds</p> <ul style="list-style-type: none"> ● Dredged material (in use) ▲ Ammunition (out of use) ▨ Dredged material (in use) ▨ Dredged material (out of use) ▨ Ammunition (out of use) <p>Mariculture</p> <ul style="list-style-type: none"> ● Culture area <p>Nature Conservation</p> <ul style="list-style-type: none"> ■ Natura2000 SPA ■ Natura2000 SAC <p>Preferred Areas</p> <ul style="list-style-type: none"> ▨ Offshore wind energy ▨ Military practise areas |
|---|---|



BUNDESAMT FÜR
SEESCHIFFFAHRT
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HYDROGRAPHIE

External Data Sources:
BfN, LANU (S-H), Environm. Ministry
Lower Saxony (Geosum), Environm. Ministry Denmark,
OPL Ltd., LBEG (Clausthal-Zellerfeld),
MAGIS, Staatliches Fischereiamt Bremerhaven,
Amt für ländliche Räume - Fischereiaufsicht (S-H),
Amt für Geoinformationswesender Bundeswehr,
Rijkswaterstaat Directie Noordzee (Netherlands),
Elsam A/S (Denmark)

The North Sea teems with fish, sea birds and marine mammals. In particular, it is home to large numbers of seals and cetaceans, the most numerous of which is the harbour porpoise. It also provides an important habitat for white-beaked and bottlenose dolphins, common and grey seals and minke whales. However, it is also subject to intense human pressures, particularly from fisheries and pollution.

The North Sea is surrounded by highly industrialised nations and has some of the world's busiest ports and shipping routes, as well as numerous off-shore oil and gas fields. Man-made noise is just one of many forms of pollution adding stress to an ecosystem already drastically altered by over-fishing and other human pressures.

Animals may remain near noise sources but this does not mean that they are not affected by them: they might remain to feed or mate even to the point of damaging their hearing.

Sound effects: how noise risks harming marine animals

The effects of man-made ocean noise on marine mammals depend on a variety of factors including the nature of the sound, its frequency, intensity and duration and the type of animal concerned. There is considerable uncertainty over the effects of noise exposure on marine animals yet as evidence has accumulated the issue has received increasing attention from scientists and international bodies.

Suggestions that man-made ocean noise poses problems for marine animals first began to emerge in the 1970s. Since then scientific studies have established that some man-made sounds can injure some marine mammals and fish, disrupt or mask crucial sounds on which they depend and also cause behavioural changes. On occasion ocean noise has even been shown to kill, with well-documented cases of fatal mass strandings of cetaceans following the use of military sonar in Greece, Madeira, Hawaii and coastal USA, the Virgin Islands, Spain, the Canary Islands and the Bahamas.¹⁵ In a 2001 joint report with the National Marine Fisheries Service the US Navy accepted for the first time that sonar used by its ships was the most plausible cause of the beaching of 16 whales in the Bahamas in March 2000.

In 2004 the Scientific Committee of the International Whaling Commission (IWC), consisting of more than 100 scientists from many countries, agreed unanimously that there was "compelling evidence implicating military sonar as a direct impact on beaked whales in particular". They also advised that "evidence of increased sounds from other sources, including ships and seismic activities, were cause for serious concern".¹⁶

There are three main areas of concern about the potential effects of ocean noise pollution on marine animals:

1. That intense noise exposure may cause death or physical injury, even at low levels for some vulnerable species (including temporary or permanent hearing loss), as well as increased stress leading to detrimental consequences for animals' immune systems and reproductive health.
2. That man-made ocean noise may mask sounds that are vital to marine animals, such as those indicating the existence and location of prey, predators and mates, as well as navigational information.

3. That noise exposure may cause behavioural changes ranging from minor to severe. Noise pollution may interfere with biologically important activities including breeding and calving and with the use of historical migration routes and feeding grounds.

A number of scientific studies have shown the effects of ocean noise pollution on behaviour:

- Bottlenose dolphins and pilot, sperm and killer whales have altered their call rates when exposed to low and mid-frequency noise sources.¹⁷
- When Gray whales were exposed to industrial sounds they left one of their breeding sites for more than five years, returning only several years after the noise stopped.¹⁸
- Loud acoustic harassment can displace killer whales and harbour porpoises over seasons or years.¹⁹

Some animals may remain near noise sources but this does not mean that they are not affected by them: they might remain to feed or mate even to the point of damaging their hearing.

Scientists reported that humpback whales exposed to explosions associated with construction off Newfoundland showed little behavioural reaction to the noise yet were subsequently much more likely to become fatally entangled in fishing nets. They concluded this "may have occurred because of sensitivity threshold shifts or damaged hearing. This suggests that caution is needed in interpreting lack of visible reactions to sounds as an indication that whales are not affected, or harmed, by an intensive acoustic stimulus".²⁰

Few studies have been able to quantify the long-term effects on marine mammals of exposure to man-made ocean noise.²¹ Whilst brief or single acute exposures to sound may injure individual animals, long-term continuous noise from multiple sources is potentially more serious as it could cause changes to behaviour and habitat use that could affect whole populations. The consequences for marine mammals of continuous exposure to increasing background noise levels in the oceans are unknown.

15 Strandings are detailed by the International Ocean Noise Coalition at http://www.awionline.org/oceans/Noise/IONC/Stranding_Tables.htm

16 IWC/SC, 2004

17 Environmental Caucus Statement, 2007

18 Weigart, 2007

19 Morton and Symonds, 2002; Olesiuk et al., 2002

20 Todd et al., 1996

21 Nowacek et al., 2007

“ Many whales have very traditional feeding grounds and their migratory routes occur along shallow coastlines, which are now some of the noisiest, most heavily impacted habitats...If females can no longer hear the singing males through the smog, they lose breeding opportunities and choices. ”

Dr Chris Clark,
Director of Bioacoustics Research Programme,
Cornell University

Scientists reported that humpback whales exposed to explosions associated with construction off Newfoundland showed little behavioural reaction to the noise yet were subsequently much more likely to become fatally entangled in fishing nets.



Humpback whale © IFAW/S. Cook

Measuring sound

There are universal standards for measuring airborne noise exposure and its effects on people, with sound levels usually being described in decibels (dB). The decibel system expresses sounds logarithmically, much as the Richter scale does for earthquakes, which results in relatively modest increases in decibels representing considerably increased sound intensities. For example, a sound that is 20 dB greater than another will be 100 times more powerful.

However, unlike other everyday measures such as centimetres and metres, decibel levels are not straightforward to interpret. With airborne noise a commonly used measure is the sound exposure level, which is the total energy of sound over time weighted according to human hearing abilities. There is no comparable standard measure for exposure to underwater noise. One of the most frequently used measures for underwater sound is the sound pressure level, which is often quoted in decibels relative to a reference pressure of one microPascal (μPa).²²

Noise exposure is determined by the intensity of the noise, its frequency, composition and duration. Intensity of noise reflects the loudness of the sound while its frequency indicates its pitch. Frequency is measured in Hertz (Hz), the number of cycles per second or is sometimes quoted in kilohertz (kHz), which are thousands of cycles per second.

Predicting how noise will change over distance is also complex. The characteristics of a sound reaching a receiver (e.g. a whale) will depend on the characteristics of the source and its distance from the receiver. Environmental factors also affect the sound including water depth, changes in the water's temperature and salinity and the topography and composition of the ocean floor.

High frequency and low frequency sounds are also affected differently. A 100 Hz sound may be detectable after propagating hundreds or thousands of kilometres whereas a 100 kHz sound may no longer be detectable after only a few kilometres. The long and low sounds that some whales have evolved to use are well suited for long-distance travel across vast areas of ocean.

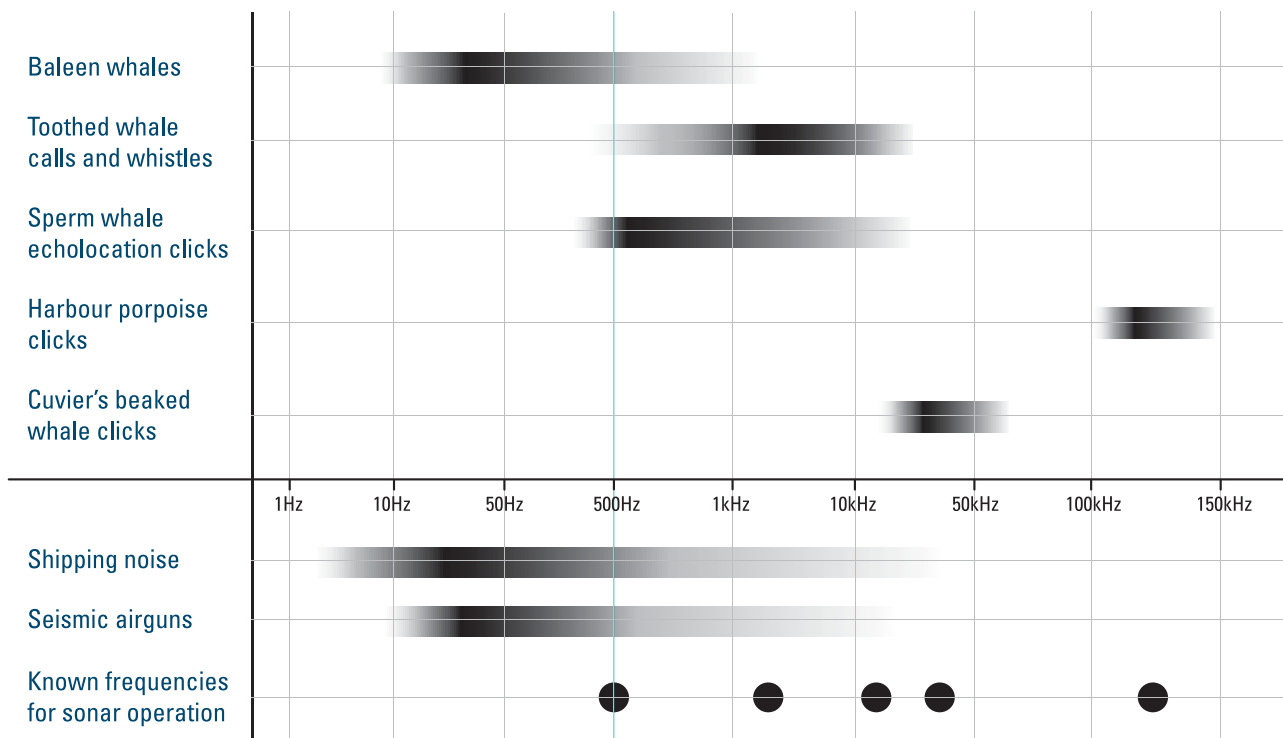
Measurements of noise at a site in the Northeast Pacific suggest that low frequency ambient noise has increased by at least 15 dB since 1950.



Seismic survey in the Arctic.

“ Pervasive shipping noise is of particular concern as it occurs in the frequency band used by baleen whales for communication. ”

US Marine Mammal Commission Report to Congress, 2007



Key:

■ Peak frequencies

Figure 2: Some examples of sound frequencies used by marine mammals and man-made sources of ocean noise pollution

Man-made ocean noise may mask sounds that are vital to marine animals, such as those indicating the existence and location of prey, predators and mates, as well as navigational information.

Notes:

- Many sounds contain energy across a wide range of frequencies that tail off either side of a peak, so trying to specify precise ranges is rather arbitrary.
- Man-made ocean noise does not have to be at the same frequency as a marine mammal's calls in order to mask them.
- There is little or no information on sounds produced by many cetaceans. In addition, the higher frequency sounds made by marine mammals that have been studied are under-reported and tend to stop at 20 kHz as this is the upper limit of commonly used recording equipment.

Case histories

Death on the beach

In March 2000, 14 beaked whales, two minke whales and one dolphin were found stranded on beaches in the Northeast and Northwest Providence Channels on the Bahamian Islands.²³ Eight of the beaked whales were returned to the water alive. The strandings occurred only hours after a mid-frequency tactical sonar exercise by the US Navy. Specimen samples from four of the dead whales showed signs of inner ear damage with one exhibiting brain tissue trauma. Following an in-depth investigation the Secretary of the Navy advised: "...mid-range tactical Navy sonar operating in the area [are] the most plausible source."

Since this stranding the area's population of beaked whales has all but disappeared, leading researchers to conclude that they either abandoned their habitat or died at sea.

Alarming, the noise levels to which the cetaceans had been exposed were well below those believed to cause temporary hearing loss. Examination of the whale carcasses from subsequent similar strandings, also believed to be related to military sonar use, showed evidence of gas bubble formation in tissues that could have been caused by the whales surfacing too quickly, rather like human divers suffering from the bends.²⁴

On occasion ocean noise has even been shown to kill, with well-documented cases of fatal mass strandings of cetaceans following the use of military sonar in Greece, Madeira, Hawaii and coastal USA, the Virgin Islands, Spain, the Canary Islands and the Bahamas.

Harbour porpoises: driven out by noise


Harbour porpoises live in some of the world's most heavily used waters and are subject to noise pollution from shipping, seismic surveys, acoustic harassment devices and off-shore construction, such as pile driving and wind farm construction. Many fish farms are located in areas of porpoise habitat. Studies in Danish and German waters have shown that noise from acoustic deterrents and marine construction can cause porpoises to move out of their preferred habitat.²⁵



23 One spotted dolphin, nine Cuvier's beaked whales, three Blainville's beaked whales, two minke whales, and two unidentified beaked whales. Eight beaked whales were returned to the water alive.

24 Cox et al., 2006

25 Tougaard et al., 2003; Thomsen et al., 2006



“ Beaked whales are reported to strand coincident in time and space to naval sonar exercises...Post-mortem analyses of whales stranded in conjunction with naval exercises have reported the presence of haemorrhaging near the ears likely to be acoustically induced. ”

W.M.X. Zimmer and P.L. Tyack,
Marine Mammal Science, 2007

Stranded Cuvier's beaked whales lie dead in Kyparisiassis Gulf, Greece, after a NATO naval exercise using sonar in May 1996.

Case histories

The threatened whales of Sakhalin

The critically endangered Western Pacific Gray whale population numbers only about 120 individuals and has only one known feeding ground, a small area off the east coast of Sakhalin Island in the Russian sector of the Okhotsk Sea. Yet this area is the focus of major oil and gas exploitation with seismic surveys and the construction of undersea pipelines and off-shore platforms. The International Whaling Commission has expressed concern regarding the survival of this population, citing underwater noise pollution as a major risk factor.

All whales close to seismic airguns are at risk of injury and behavioural disruption but at Sakhalin these concerns are particularly significant because it is the only known feeding ground for these whales, which have a very limited season in which to feed and store fat for the entire year. Research has indicated that whales left their feeding area during seismic surveys and returned only days after they ceased.²⁶ The whales also appeared to swim faster and surface for shorter intervals during seismic surveys. These responses may well result in decreased foraging success - indeed, several individuals in this population have shown evidence of being under-nourished and have been described as 'skinny'.²⁷

Repeat seismic surveys are planned from 2009 onwards in areas close to the Gray whale habitat. The oil companies concerned claim it is necessary to repeat previous surveys exactly, meaning there is no possibility of using different equipment that might perform the same job and cause less disturbance.

Humpback whales: singing a new song

The songs of the humpback whale are among the most complex in the animal kingdom. Male humpback whales sing in their breeding areas and while migrating to and from their feeding grounds. Although not like human language, recent research has revealed that humpback songs do contain elements of language.²⁸ The ways in which individuals learn and copy songs are also unique in the animal kingdom.²⁹ Studies have shown that humpbacks alter their songs in response to noise: the length of their mating song increases in response to low frequency sonar, perhaps in an effort to compensate for the interference.³⁰



26 Weller et al., 2002

27 Brownell and Weller, 2002

28 Suzuki et al., 2006

29 Noad et al., 2000

30 Miller et al., 2000

“ The critically endangered population of western Gray whales...can ill afford even a temporary displacement from its summer feeding grounds, where it is subject to potential impact from extensive oil and gas exploration. ”

Douglas P. Nowacek et al,
Mammal Review, 2007



Case histories

Killer whales: struggling to be heard

Vocal communication seems particularly important to killer whales, which have a complex repertoire of calls and may rely on sound for cooperative foraging. Those living in stable family groups (pods) have developed their own "dialects" and call types.³¹ In areas where recreational and whale watching boats are prevalent local killer whale populations are exposed to noise for considerable amounts of time. Research has shown that this noise can mask killer whale calls at ranges of over 10km.³² When the noise reaches a critical level the whales begin making longer calls³³, an indication that they are struggling to communicate.



When the noise reaches a critical level the whales begin making longer calls, an indication that they are struggling to communicate.

Other marine victims of ocean noise pollution

While hearing is of secondary importance in prey location for seals they use acoustic signals for communication, which includes maintaining mother and pup contact and attracting mates. It is possible that construction and other operational noise could mask such signals and severely impact on seals.³⁴

Many fish have sensitive hearing and use sound to communicate, locate prey and detect predators.³⁵ Hearing sensitivity varies greatly between species but as is the case with marine mammals noise exposure can cause permanent or temporary loss of hearing in fish. Fish with damaged hearing may be unable to communicate, locate predators or prey or otherwise sense their acoustic environment. It is also possible that intense low frequency sounds interfere with communication during important activities such as spawning.³⁶

Displacement of fish by man-made noise has implications for predators and fisheries as well as for the fish themselves. One study in the North Sea found that when cod and haddock were exposed to airgun noise from seismic surveys the result was an immediate reduction in trawl catches for both species.³⁷

It is likely that marine turtles, diving seabirds and many other species may also be affected by ocean noise pollution.

31 Ford, 1991; Deecke et al., 2000

32 Erbe, 2002

33 Foote et al., 2004

34 Lucke et al., 2008

35 Hawkins, 1993

36 ICES, 2005

37 Engås et al., 1996

Summary: effects of ocean noise pollution

All species with sensitive hearing will suffer permanent or temporary hearing loss at high levels of sound exposure.



Overwhelming evidence that military sonar has caused the deaths of beaked whales and other species.



Acute noise effects not only occur at high sound levels but also at relatively low sound levels when certain activities are disturbed.



Whales may move away from preferred habitat in response to seismic surveys.



Synergistic effects with chemical pollutants (e.g. exposure to a combination of noise and organic solvents) might occur that would not have been expected at the level of exposure to either pollutant on its own.



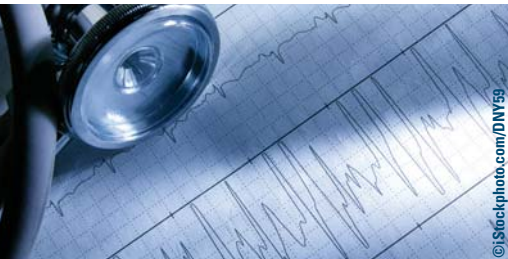
Porpoises may move away from an area with pile driving noise.



Noise causes stress which results in changes in blood pressure, heart rate, cardiac output and vasoconstriction. There is increasing evidence of an association between transportation noise and cardiovascular risk.



Marine mammals may stop foraging or change their behaviour patterns in response to acoustic disturbance.



Marine mammals may change their vocalisations in an attempt to be heard over the noise.



Recognition of the threat: international calls for action

The regulation of airborne noise pollution has been driven by concerns over human health and well-being. Limits are set for total exposure to noise in the workplace and for a variety of loud noise sources such as aircraft, vehicles and other installations. However, ocean noise pollution creates far fewer human health concerns and the need for its regulation because of its impact on marine wildlife has been recognised only recently. Since man-made noise can propagate across vast stretches of ocean and affects waters outside national control - and also because some marine species migrate hundreds of miles - it is an issue that needs international regulation.

In recent years international bodies have recognised ocean noise pollution as a threat to marine life and have called for research, monitoring and multilateral action. Since 1991 the **International Maritime Organization (IMO)** has recognised that ocean noise from ships may adversely affect the marine environment.³⁸ In April 2008 its Marine Environment Protection Committee invited governments to inform and invite all interested national entities to participate in the ongoing dialogue on potential adverse impacts associated with vessel noise and their mitigation.

Since 2005 the **Secretary-General of the United Nations (UN)** has included ocean noise pollution in his annual report on Oceans and the Law of the Sea to the UN General Assembly. In 2005 man-made underwater noise was described as one of five "current major threats to some populations of whales and other cetaceans" and as one of the 10 "main current and foreseeable impacts on marine biodiversity". The report noted that despite concerns expressed in several frameworks "there is no international instrument directly aimed at controlling underwater noise". In 2006 the Secretary-General noted the increasing concern among scientists that noise pollution poses a significant and, at worst, lethal threat to marine life including fish. In both 2007 and 2008 the report noted the continuing calls for action by international organisations.

The **UN General Assembly** has encouraged further studies and consideration of impacts of ocean noise on marine living resources in its 2006 and 2007 omnibus resolutions on oceans.

The **Convention on the Conservation of Migratory Species of Wild Animals** (also known as CMS or Bonn Convention) adopted a resolution in 2005 calling for the development of measures to protect cetaceans from adverse human-induced impacts and identified marine noise as a potential threat to their populations. The CMS, which is supported by over 100 parties from Africa, Central and South America, Asia, Europe and Oceania, has created two European regional agreements on the conservation of cetaceans.³⁹ Both have identified ocean noise pollution as a major threat to cetaceans and have established working groups to address man-made noise sources including sonar, seismic surveys, off-shore construction and commercial shipping and their impacts.

Man-made noise has been on the agenda of the **International Whaling Commission (IWC)** since 1998 when it was identified as a priority for investigation by its Scientific Committee. In 2004 the Committee made a number of recommendations including for seismic operators to seek ways to mitigate their potential impacts and to time surveys to avoid the presence of populations of large whales. In 2007 the Committee expressed serious concerns again and made further recommendations to be followed, for example during the planning of naval training exercises.

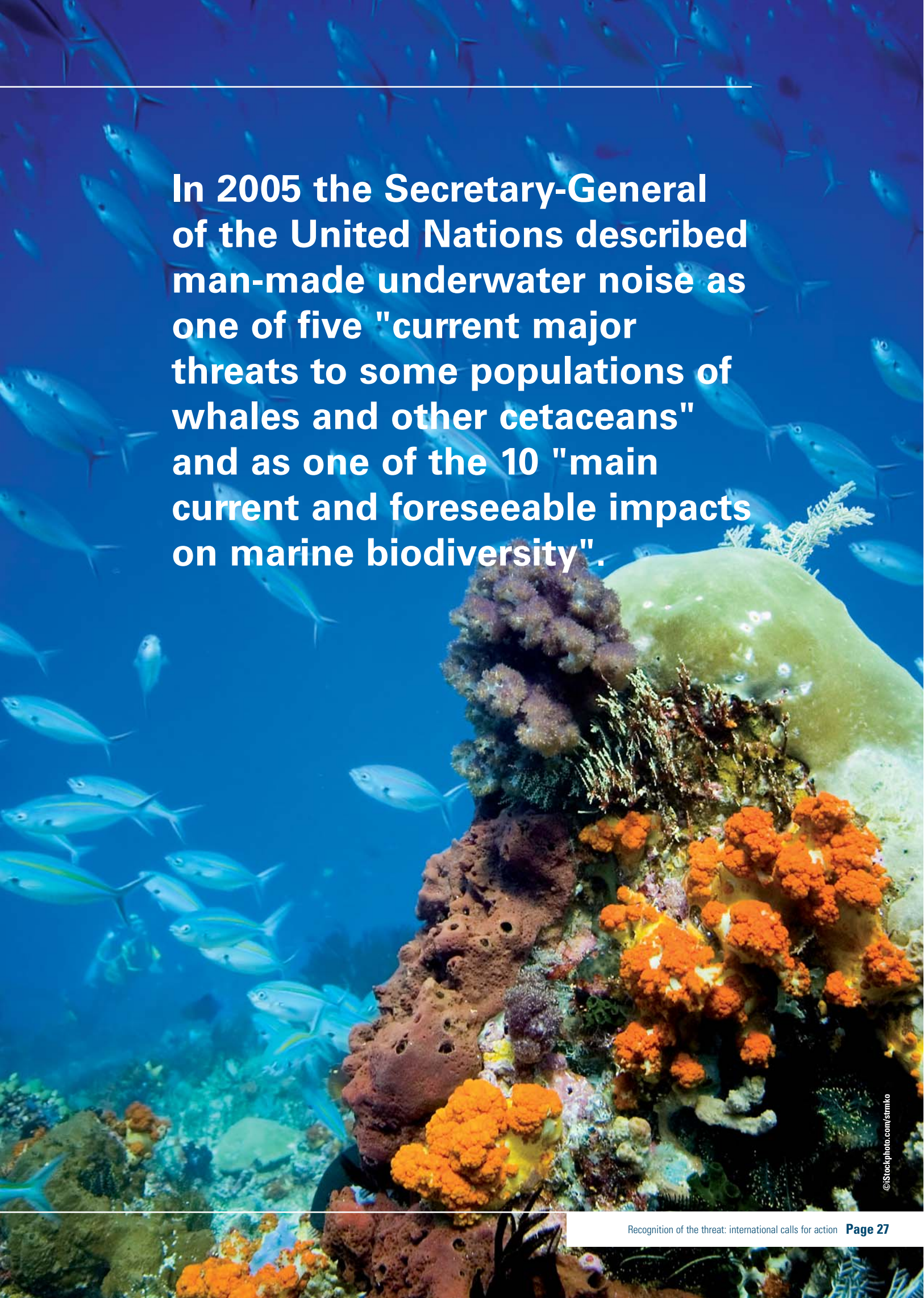
The **European Union (EU)** has acknowledged the problem of ocean noise pollution since 2002 when the consultation process began on its Marine Strategy Directive. In 2004 the European Parliament adopted a resolution calling on EU member states to impose a moratorium on the use of high intensity sonar in naval operations.

Further information on international recognition of ocean noise pollution and on calls for action by these and other bodies is listed in Appendices 2 and 3.

In recent years international bodies have recognised ocean noise pollution as a threat to marine life and have called for research, monitoring and multilateral action.

³⁸ Guidelines for the Designation of Special Areas and the Identification of Particularly Sensitive Sea Areas, IMO Resolution A.720(17), 1991, as replaced by IMO Resolution A.982(24), 2005

³⁹ ASCOBANS and ACCOBAMS - see Appendices 1 and 3 for further details



In 2005 the Secretary-General of the United Nations described man-made underwater noise as one of five "current major threats to some populations of whales and other cetaceans" and as one of the 10 "main current and foreseeable impacts on marine biodiversity".

Instruments for the regulation of ocean noise pollution

The 1982 UN Convention on the Law of the Sea (UNCLOS) provides the international legal framework for all human activities at sea and requires states to “prevent, reduce and control pollution of the marine environment from any source”. Man-made ocean noise implicitly falls within the definition of pollution under UNCLOS and is covered by its provisions. With the exception of some standards for shipping there is no limit to the types of measures that coastal states may adopt in waters under their sovereignty and jurisdiction as long as they do not interfere with legitimate uses of the sea by other states (e.g. navigational rights). However, in areas beyond national jurisdiction international cooperation and agreements are needed to regulate noise-producing activities and coordinate national efforts.⁴⁰

Other international agreements and bodies also offer opportunities to regulate ocean noise pollution: their requirements are consistent with the general provisions of UNCLOS and they can provide for the implementation of specific measures. Further details appear in Appendix 1.

In May 2008 the EU adopted a Marine Strategy Directive that explicitly includes underwater noise in the definition of pollution and requires EU member states to control its adverse effects.

“ We must acknowledge that a number of existing as well as new and emerging activities and threats in Areas Beyond National Jurisdiction are de facto unregulated or insufficiently regulated... Activities, for which detailed international rules and standards are currently lacking, include...ocean noise ...The EU stresses the need to address these gaps. ”

Statement on behalf of the European Union at the United Nations' General Assembly NGA Ad-Hoc Open Ended Working Group to study issues relating to the conservation and sustainable use of marine biodiversity beyond areas of national jurisdiction, 2008



IFAW: taking action on ocean noise pollution

IFAW is campaigning to raise awareness of ocean noise pollution as a growing problem and to encourage the international community to find solutions. Our cutting edge marine mammal research vessel *Song of the Whale* (see pages 30-31) is a major tool in this endeavour. IFAW has also funded other research as well as presenting evidence on ocean noise to international and national bodies including the US Marine Mammal Commission's investigation into man-made ocean noise.

In particular IFAW is working with the Natural Resources Defense Council (NRDC), the Ocean Futures Society, the Whale and Dolphin Conservation Society (WDCCS) and other like-minded organisations to improve protection for whales from harmful human-generated noises, with emphasis on high intensity military active sonar systems.

Naval sonar litigation

IFAW has been using the US court system to restrict the use of naval sonar, winning two important victories to date. In February 2008 a lawsuit filed by IFAW and five other groups led to a US federal court in California granting a preliminary injunction against the US Navy restricting its use of low frequency active (LFA) sonar during testing and training operations. In particular the injunction bans LFA sonar use in various areas of critical marine mammal habitat around the world.

The same month, in another case brought by IFAW and other organisations, a second US federal court rejected an attempt by the Bush Administration to override protection for marine mammals from high intensity mid-frequency active (MFA) sonar naval training operations. This ruling was upheld by a federal appeals court. The US Justice Department has asked the US Supreme Court to review the appeals court decision. At the time of writing a decision was pending from the Supreme Court on whether or not it will review the case.

EU policy work

IFAW campaigned successfully for underwater noise to be recognised and regulated as a form of pollution in the EU Marine Strategy Directive, which was adopted in May 2008. As a result the Directive is the first international legal instrument to explicitly recognise underwater noise as a pollutant that must be controlled by member states to achieve the good environmental status of EU waters by 2020.

In 2004 our joint campaigning with other organisations led to the European Parliament's adoption of a resolution on the environmental impacts of high intensity active naval sonar. The resolution calls on EU member states to work to suspend the use of high intensity active sonar in naval operations, to restrict immediately its use in waters under their jurisdiction and to develop alternative technologies.

IFAW has also been urging the European Commission to consider ocean noise pollution in all relevant EU policies and legislation including the EU Maritime Policy. In 2007 this helped prompt a section on underwater noise being included in the guidelines for the establishment of the Natura 2000 network in the marine environment, recommending EU member states to adopt noise management measures in marine sites.⁴¹

On 3 January 2008 in a US federal court in California the Honorable Florence-Marie Cooper issued an injunction to protect marine mammals from high intensity mid-frequency active (MFA) sonar naval training operations. Judge Cooper described key elements of the Navy's mitigation scheme as "grossly inadequate to protect marine mammals from debilitating levels of sonar exposure".⁴²

⁴¹ see: http://ec.europa.eu/environment/nature/natura2000/marine/index_en.htm

⁴² An appeal against this judgement failed in February 2008. The US Justice Department has asked the US Supreme Court to review the appeals court decision.

IFAW's *Song of the Whale*

Since 1987 IFAW's research vessel *Song of the Whale* has provided a unique platform for marine research and education. It is a boat with a pressing mission: to improve our understanding of cetaceans and generate public and political support for their protection. With custom-made observation platforms, specialised software and bespoke recording systems *Song of the Whale* is one of the most effective non-invasive whale research vessels in the world.

Silence in action

In 2004 the original *Song of the Whale* was replaced by a larger vessel with greatly extended capabilities. Designed to a special brief, the new *Song of the Whale* has numerous features to ensure it is as quiet as possible. First and foremost the boat is a sailing vessel. During those times when its engine or generator is required it is important that underwater noise does not disturb the study animals. To reduce noise emissions the engine and generator are on soft rubber mounts and the engine room has special sound insulation. The transmission and exhaust systems are also designed to reduce noise and vibration. The boat has a specially designed propeller based on technology used in submarines.

Maximum research, minimal disturbance

Special underwater microphones and computer software developed by the team allow them to carry out benign research. The team has developed a particular expertise in passive acoustics (listening to the sounds made by marine mammals) to identify, track and survey different species. This expertise is used to find practical solutions to the problems threatening cetaceans and to identify emerging problems so that positive action can be taken. Thousands of hours of listening to the underwater environment has also made the team particularly aware of the problem of man-made ocean noise.

Beaked whales

In May 2008 *Song of the Whale* began a research project to investigate the efficiency of using acoustics to detect beaked whales, which are particularly difficult to study because they are oceanic, dive deeply and are hard to spot at sea. The aim is to develop a better understanding of beaked whale distribution patterns and habitat requirements to help address threats such as ocean noise pollution. Beaked whales make short bursts of high frequency clicks but are much less vocal than many other species. A combination of visual and acoustic monitoring in known areas of beaked whale habitat will allow acoustic detection systems to be refined and evaluated.

Right whales

The *Song of the Whale* team has been studying the North Atlantic right whale, one of the world's most endangered, since 1997. This work, in conjunction with Cornell University, has led to the development of off-shore, real time acoustic detection buoys that can identify whale calls and relay messages to the shore. These buoys are currently being trialled off the east coast of the USA with the aim of reducing ship-whale collisions.

Sperm whales

The *Song of the Whale* team has developed methods that have been used around the world to survey for sperm whales by monitoring the sounds that they make. Specialist software is used to detect the distinctive 'clicks' of sperm whales and measure their bearing relative to the survey vessel. This information is used to locate each animal that is heard, allowing the number of whales in a known area to be estimated.

Porpoises

Much of *Song of the Whale's* work has used acoustic techniques to examine potential interactions between porpoises and fisheries. Distribution surveys in the Baltic Sea confirmed fears that harbour porpoise numbers are dangerously low and urgent action is needed to prevent continued deaths in fishing gear. IFAW's harbour porpoise survey techniques have also been used on European-wide surveys, which will help reveal the distribution of these mammals in relation to threats, including ocean noise pollution.

“ In 2007 we surveyed 17,000 km of the Eastern Mediterranean and ship noise was acute. It was widespread, pervasive and penetrated even remote off-shore regions. While noise from seismic and sonar activities was more sporadic it tended to be exceedingly loud. ”

Dr Olly Boisseau,
Song of the Whale research scientist

Sea trials have shown that *Song of the Whale* is exceptionally quiet, allowing the team to listen for sounds from whales that would be drowned out by the noise from most comparable vessels.



Tackling ocean noise pollution: the need for precautionary action

At present the full animal welfare, biological and conservation implications of ocean noise pollution are unknown. What evidence we do have indicates that, at very least, noise has serious welfare implications for marine mammals and at worst the potential to disrupt entire ecosystems. Waiting for conclusive proof before taking action, however, would be a mistake as environmental science rarely provides it. Moreover, research to more fully assess the impact of ocean noise pollution might not yield answers for decades. It is essential that precautionary measures are introduced without delay to reduce man-made ocean noise and to mitigate its effects.

The need to adopt precautionary measures is especially important given that many marine animal species are already endangered or threatened and are subject to the cumulative effects of a multiplicity of pressures including chemical pollution, fisheries (by-catch and entanglement in nets), collisions with ships and climate change. Moreover, accurately measuring human impacts upon them is exceptionally difficult over vast ocean areas.

The effects of ocean noise pollution on marine life are best addressed by reducing the intensity and duration of noise from its various sources. Another approach is to keep loud sources away from sensitive species, for example by the imposition of seasonal and geographical exclusions from biologically important areas.

With growing evidence of the impacts of man-made ocean noise, producers of some of the loudest intentional sounds, such as airguns and military sonar, have acknowledged the need for and adopted mitigation measures. Noise producers often argue such action shows they are taking environmental considerations seriously. But these arguments need to be supported by a careful evaluation of the level of risk reduction that is likely to be achieved.

Reducing shipping noise pollution

The technologies to make very quiet ships are well established. As well as the development of the near silent propeller by military designers, fishery research vessels are built to be as quiet as possible so as not to disturb fish during surveys. Some technologies to make cruise ships quieter for passengers can also reduce man-made noise. Subtle changes in design can also make big differences to

the noise output from a vessel. For most merchant vessels, however, noise has never been a consideration so there is plenty of scope for making ships quieter. Designing and building quieter ships need not be costly. Noise represents wasted energy and so quieter ships may also use less fuel.

Requiring vessels to avoid biologically important marine mammal habitats is another way of reducing the potentially damaging effects of shipping noise pollution. This mitigation also has the added benefit of reducing the risk of collisions with whales. Where re-routing vessels is not possible, speed restrictions may also reduce noise and collision risk.

Unfortunately only a very small percentage of the commercial shipping industry is even aware that sound generated underwater may be a problem for marine mammals, as was highlighted in 2007 by Kathy J. Metcalf, Director of Maritime Affairs at the Chamber of Shipping of America. Metcalf advised the US Marine Mammal Commission that while not suggesting all ships need to use noise reduction technologies, the issue "necessitates an aggressive education and outreach campaign designed to reach all the necessary experts (ship owners, naval architects, design engineers, ship routing specialists) so that the general nature of the problem is made known and its potential impacts and possible mitigation measures may begin to be identified".⁴³

The US National Oceanic and Atmospheric Administration (NOAA) has been promoting dialogue between the shipping industry, governments, academics and NGOs "to consider the potential impacts of noise from large vessels on marine life and possible ways to mitigate the impacts through ship design and operational modifications".⁴⁴

Noise represents
wasted energy and
so quieter ships may
also use less fuel.

⁴³ Metcalf, 2006

⁴⁴ The NOAA hosted two international symposia in 2004 and 2007: findings available at <http://www.nmfs.noaa.gov/pr/acoustics/shipnoise.htm>

“ One of the biggest challenges faced in regulating the effects of noise is our ignorance of the characteristics and levels of sound exposures that may pose risks to marine mammals. Given the current state of our knowledge we must therefore take a precautionary approach in the regulation of noise. ”

Gianni Pavan,
Interdisciplinary Centre for Bioacoustics and Environmental Research,
Universita' degli Studi di Pavia, Italy

Mitigation measures for military sonar

Navies employing high intensity sonar use crew as marine mammal observers and passive acoustic monitoring as mitigation measures. However, the proportion of animals detected by observers may be very small. One study estimated that visual mitigation monitoring for beaked whales - the species about which there is most concern - is likely to detect fewer than two per cent of those whales directly in the paths of ships.⁴⁵

A more effective mitigation measure would be to avoid sonar use in areas that are of particular biological importance, for example feeding, breeding and birthing areas and the migratory paths of marine species that are vulnerable to ocean noise pollution. Risks would be further reduced if military exercises featuring high intensity sonar were restricted to areas where the most vulnerable species are unlikely to be present. In line with the precautionary approach it should be the responsibility of noise producers to demonstrate that use of sonar within an area presents a low risk to marine life.

Beaked whales are particularly at risk yet we know little about where they are likely to be found. Since these whales are hard to spot during their brief surfacing IFAW is working to develop passive acoustic methods for detecting them (see page 30).

In 2004, responding to a series of whale strandings and mortalities following military training exercises, the Spanish Ministry of Defence announced a prohibition of active sonar exercises within 50 nautical miles of the coastline of the Canary Islands.⁴⁶ In October 2002, August 2003 and again in February 2008 a federal court in California imposed an injunction on the US Navy prohibiting the use of low frequency sonar in various areas of critical marine mammal habitat. The injunction stemmed from a lawsuit filed by IFAW and other organisations.

The prohibition of active sonar exercises within 50 nautical miles of the Canary Islands is 'the first government action of its kind to exclude active naval sonar from waters that have been shown to shelter particularly sensitive species'.

Sarah Dolman,
*Journal of International
Wildlife Law and Policy, 2007*



A stranded Cuvier's beaked whale lies dead in the Canary Islands after an international naval exercise using sonar in September 2002.

“ Particularly in the case of training exercises with high intensity sonar, sufficient planning and environmental review must be required to enable low risk areas to be identified, sensitive areas to be avoided, and comprehensive mitigation protocols to be implemented. Simply stated, whales and other marine life should not have to die for practice. ”

Joel Reynolds,
Natural Resources Defense Council, 2008



Mitigation measures for seismic surveys

In some countries and regions the relevant authorities have included measures within their oil and gas licensing agreements aimed at reducing impacts from seismic airgun sound on marine mammals.⁴⁷ Unfortunately their effectiveness is typically low or unknown.

A common practice is the use of observers to detect whales and other marine mammals, with survey operations then being suspended while cetaceans are nearby. However, even in good conditions, only a limited proportion of whales entering the “danger zone” are likely to be detected in time and inconspicuous animals such as harbour porpoises are unlikely to be spotted at all. Furthermore, seismic surveys are often carried out at night or during periods of poor visibility. Listening for whales (passive acoustic monitoring) can improve the chances of their detection and current best practice is to combine this with visual monitoring. Nevertheless, many animals will still not be detected.

Oceanographic conditions may also result in whales further away from the source being exposed to much greater noise levels than might be expected. A study in which sound recording devices were attached to sperm whales in the Gulf of Mexico found that received levels from seismic airguns could be as high at a distance of 12 km as they were at 2 km from the source.⁴⁸

The use of a “soft start” or “ramp-up” is also common, working on the assumption that a gradual increase in sound levels gives whales and seals sufficient time to leave the area. To date it has not been verified whether they actually do so.

In 2007 the US Marine Mammal Commission advised in its report to Congress that unnecessary sound production should be minimised, for example by avoiding “repetitious seismic surveys of the same area when a single, comprehensive survey will suffice to provide the information needed by the oil and gas industry”.

Following an unusually high number of humpback whale strandings after the first seismic surveys in the Abrolhos Bank Marine Park, Brazil introduced a buffer zone around the area to protect marine species, particularly breeding humpback whales. Australia has also introduced a Marine Mammal Protection Zone within the Great Australian Bight, placing a specific area off limits to oil and gas exploration because of the presence of southern right whales and Australian fur seals.⁴⁹

Mitigation measures for off-shore pile driving

The development of off-shore wind farms has resulted in construction noise in areas that may also be important marine mammal habitat. Noise from pile driving is sufficiently intense as to pose a risk of hearing loss at close range. Mitigation measures currently being considered include ‘curtains of bubbles’ or fixed screens around the piles to act as sound barriers. A recent report found that bubble curtains were unlikely to work well in areas with significant tidal currents but that fixed screens could be effective. A possible alternative is the use of acoustic scaring devices to try to keep marine mammals sufficiently far away from noise sources to avoid physical injury. However, this would add to overall noise levels and further research is needed to establish whether such an approach would work.

Mitigation measures for acoustic harassment devices

Acoustic harassment devices are used around fish farms instead of more expensive anti-predator nets in the hope of deterring seals. There is no clear evidence, however, that harassment devices reduce the risk of seal damage to aquaculture installations but there is evidence that they can exclude cetaceans from preferred habitat. The loud, unpleasant sounds generated by these devices raise serious animal welfare concerns, particularly for seals, dolphins and porpoises.

Mitigation measures for recreational boating

There are several simple steps that small craft users can take to reduce their noise output. These include making sure the propeller is clean and undamaged, keeping engine revs below the speed at which the propeller cavitates, not putting engines into reverse close to marine mammals and turning off depth sounders when not in use.

Depth sounders are widely available at boating supply stores and use acoustic pulses to measure the depth under a boat, with many using frequencies audible to cetaceans. Scientists have commented that while the energy of these devices is generally directed downwards their sheer number, particularly in coastal waters, makes them a concern.⁵⁰

47 Including Australia, Brazil, California, Canada, Gulf of Mexico, New Zealand, Sakhalin and UK. The UK guidelines are often perceived as causing the least disruption to a survey and are often used by operators in regions without statutory guidelines. Weir and Dolman, 2007.

48 Madsen et al., 2006
49 Dolman, 2007

50 Nowacek et al., 2007

“Currently, none of the available detection methods (visual search and passive acoustic monitoring) has a high probability of detecting and identifying beaked whales.”

Jay Barlow and Robert Gisiner,
Journal of Cetacean Research Management, 2006



Cuvier's beaked whale off the Canary Islands. Beaked whales are extremely elusive and rarely spotted at the surface.

Conclusions and Recommendations

While the full impact of ocean noise pollution is yet to be determined there is international recognition that it poses a serious threat that must be addressed. The next steps are to translate recognition of the problem into effective solutions.

IFAW considers that the two key objectives are to reduce levels of background noise from man-made sources throughout the world's oceans and to prevent the exposure of marine life to harmful high intensity sound.

Ocean noise pollution should be tackled in a similar way to other pollutants through a broad suite of measures including raising awareness, voluntary measures such as industry codes of conduct and properly enforced regulations. IFAW's national offices have specific recommendations for their own regions.

Internationally, IFAW recommends that:

Industry, governments and research institutions shall:

- Facilitate increased research directed towards engineering solutions that reduce noise at source. This would include better signal processing to reduce the minimum sound levels necessary for navigational sonar and seismic airguns and to eliminate unused frequencies.
- Require noise to be a key consideration from the design stage and throughout the operation of all types of vessels from commercial supertankers to recreational jet skis. Particular attention needs to be given to reducing noise from the loudest ships.
- Provide reliable data on cetacean distribution and migration to identify high risk areas.

International bodies, competent national authorities and enforcement agencies shall:

- Recognise man-made ocean noise as a form of pollution and regulate it accordingly within the framework of all national and international legislation governing human activity at sea and the protection of marine life and marine ecosystems (see Appendix 1).
- Ensure that existing legislation and resolutions (see Appendices 2 and 3 for details) are effectively implemented and enforced.
- Ensure that ocean noise-producing activities are subject to existing or new environmental impact assessment legislation that fully addresses the cumulative effects of human pressures on marine biodiversity. In addition, international standards or guidelines should be developed to implement environmental impact assessments in areas beyond national jurisdiction.
- Regulate high intensity active sonar in the world's oceans because of its harmful effects on marine mammals, fish and possibly marine ecosystems.
- Adopt a precautionary approach so that, prior to any high intensity sound activity, operators are required to quantify the risk reduction brought about by their mitigation measures in order to demonstrate their effectiveness to the competent management authorities.
- Prohibit loud sound sources, such as seismic airguns and sonar, in sensitive and protected areas designated for marine species that are vulnerable to ocean noise pollution.
- Ensure that the use of acoustic devices to protect fisheries from predators is based on solid scientific evidence that these are genuinely effective with any such use being dependent on the outcome of a comprehensive environmental impact assessment of the likely effects on other species.

All users of the oceans who generate high intensity sounds shall:

- Recognise that current mitigation measures are insufficient to deal effectively with ocean noise pollution and work within their respective industries to raise awareness of the issue and the need for a precautionary approach.
- Embrace technology for reducing noise and work within conservative noise standards set by appropriate regulatory bodies.

Finally, IFAW urges international bodies, governments, industry and marine protection, conservation and animal welfare organisations to work together to combat the rising threat posed by ocean noise pollution.



The two key objectives are to reduce levels of background noise from man-made sources throughout the world's oceans and to prevent the exposure of marine life to harmful high intensity sound.

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Appendix 1

Examples of international agreements and bodies that provide opportunities to address ocean noise pollution

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International Maritime Organization (IMO) is the competent international body to regulate the environmental impact of shipping. The prevention, mitigation and control of ship-generated noise pollution implicitly fall within its regulatory mandate.

International Seabed Authority (ISA) is the responsible body for preventing pollution arising from activities in the international seabed. The prevention, mitigation and control of ocean noise pollution arising from activities, including exploration and seismic surveys, in this area implicitly fall within its competence.

International Convention for the Regulation of Whaling (ICRW) was set up initially to regulate whaling and may adopt regulations with respect to the conservation and utilisation of whale resources. Work on ocean noise would be justified under Article IV(1) which allows studies on whales or whaling. The International Whaling Commission (IWC) operates under the auspices of the ICRW. In recent years the IWC and its Scientific Committee have given increased consideration to threats not directly related to whaling, including noise pollution and seismic surveys in particular.

UN Convention on Biological Diversity (CBD) requires parties to identify activities under their control which have, or are likely to have, a significant adverse impact on biodiversity and to regulate and manage those activities, including through the establishment of protected areas for biodiversity conservation. This may provide a legal basis for the regulation and management of high intensity sources of noise such as military sonar and seismic testing.

UN Convention on the Conservation of Migratory Species of Wild Animals (CMS) requires parties to endeavour to prevent or minimise as appropriate the adverse effects of activities that endanger Appendix 1 species, which include 11 species of cetaceans, and to prohibit their harassment. Ocean noise pollution, especially high intensity sounds, could be classified as an "adverse effect" or a form of harassment.

Several agreements on the conservation of migratory species under the CMS also provide opportunities for regulating noise pollution at the regional level. Most progress has been made through the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area (ACCOBAMS). In 2007 the 3rd Meeting of the Parties established a working group to address man-made ocean noise from a number of activities including seismic surveys and military sonar "in order to develop appropriate tools to assess the impact of anthropogenic noise on cetaceans" and to "elaborate measures to mitigate such impacts".

UN Fish Stocks Agreement (UNFSA) requires among other things that parties ensure the long-term conservation of straddling and highly migratory fish stocks and minimise pollution and impacts on associated or dependent species, in particular endangered species. This could include protection from noise pollution, particularly if caused by fishing activities.

The Helsinki Convention sets up the legal framework for protecting the marine environment of the Baltic Sea from "all sources of pollution" and specifically requires states to take action to reduce ocean noise from pleasure craft.

OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) requires parties to take all necessary measures to protect and conserve biological diversity and to protect the environment against pollution "from other sources" to the extent that such pollution is not already effectively regulated under existing international conventions, as would be the case for ocean noise pollution.

Bern Convention on the Conservation of European Wildlife and Habitats sets forth obligations to conserve some species of cetaceans and preserve their habitats from threats including "disturbance".

UNEP Barcelona Convention sets out the framework to prevent, control and eliminate pollution in the Mediterranean Sea. The Specially Protected Areas (SPA) Protocol to the convention requires states to regulate and (where appropriate) prohibit activities having “adverse effects” on endangered and threatened species listed in Annex II (which includes 19 species of marine mammals) and to control and prohibit the “disturbance” of wild fauna, implicitly including ocean noise pollution.

Environmental Protocol to the Antarctic Treaty sets forth obligations to ensure that no activities in the region cause detrimental changes to the distribution, abundance or productivities of marine species or further jeopardise endangered/threatened species or populations. The Antarctic Treaty, moreover, prohibits all military activities in the region, including sonar testing.

The European Union explicitly includes underwater noise in the definition of pollution in its 2008 Marine Strategy Directive, in which action is required by member states. In addition, ocean noise pollution is covered indirectly by the Habitats Directive, which prohibits all forms of “deliberate disturbance” of cetaceans. The 2007 Guidelines for the Establishment of the Natura 2000 Network in the Marine Environment recommend the adoption of noise management measures in marine sites.

Appendix 2

United Nations’ calls for action on man-made ocean noise

United Nations’ Informal Consultative Process on Oceans and the Law of the Sea (UNICPOLOS)

2004: identified ocean noise pollution as an issue that could benefit from attention in future work of the UN General Assembly (UNGA).

2005: called on the UNGA to request “further studies and consideration of the impacts of ocean noise on marine living resources.”

2006: urged the UNGA to promote understanding, through increased research, of the impacts of underwater noise on marine ecosystems in order to implement the ecosystem approach.

UN Secretary-General Reports on Oceans and the Law of the Sea

2005: man-made noise recognised as one of five “current major threats to some populations of whales and other cetaceans” and as one of the 10 “main current and foreseeable impacts on marine biodiversity” on the high seas. This report also called for better “assessment of the impacts of underwater noise on acoustically sensitive oceanic species, including fish and cetaceans, as well as consideration of noise abatement strategy” and noted that despite the concerns expressed in several frameworks “there is no international instrument directly aimed at controlling underwater noise”.

2006: recognised that “there is an increasing concern among scientists and conservationists that noise pollution poses a significant and, at worst, lethal threat to whales and dolphins and other marine wildlife including fish”.

2007: acknowledged that “concerns that ocean noise may pose a threat to the marine environment are growing, along with continuing calls by international organisations for further research, monitoring and the minimisation of the risk of adverse effects of ocean noise”.

2008: acknowledged continuous international calls for action and announced the publication on the UN Division on Ocean Affairs and the Law of the Sea (DOALOS) website of lists of peer-reviewed scientific studies on the impacts of ocean noise on marine living resources that it has received from UN governments as requested by the UNGA. See: http://www.un.org/depts/los/general_assembly/noise/noise.htm

UN Informal Working Group on Marine Biodiversity beyond National Jurisdiction

First meeting (2006): man-made ocean noise identified as a “growing human pressure” that “require[s] urgent action through international cooperation and coordination”.

Second Meeting (2008): man-made ocean noise identified among the pressures on marine biodiversity beyond areas of national jurisdiction that require particular attention.

UNGA Omnibus Resolutions on Oceans and the Law of the Sea

Since 2005: regular calls for further studies and consideration of the impacts of ocean noise on marine living resources.

2006 and 2007: requested DOALOS to compile the peer-reviewed scientific studies it receives from member states and to make them available on its website.

Appendix 3

Other international calls for action

IWC

- Resolution 1998-6 on “Undersea Noise Pollution”.
- Scientific Committee 2004 and 2007.

CMS

- Resolution 7.5 (2002) on “Potential Impacts to Marine Mammals from Emissions of Noise and Vibrations into the Waters from Wind Turbines”.
- Resolution 8.22 (2005) on “Adverse Human Induced Impacts on Cetaceans”.

ACCOBAMS

- Scientific Committee Recommendation 2.7 (2003) on “Man Made Noise”.
- Resolution 2.16 (2004) on “Assessment and Impact Assessment of Man Made Noise”.
- Resolution 3.10 (2007) on “Impact of Anthropogenic Noise on Marine Mammals in the ACCOBAMS Area”.

ASCOBANS

- Resolution 5 (2003) on “Effects of Noise and of Vessels”.
- Resolution 5.4 (2006) on “Adverse Effects of Sound, Vessels and Other Forms of Disturbance on Small Cetaceans”.

OSPAR

- 2003 Initial List of Threatened and/or Declining Species and Habitats in the OSPAR Maritime Area.
- 2003 Guidelines for the Management of Marine Protected Areas in the OSPAR Maritime Area.
- OSPAR Biodiversity Committee Report on the Impact of Underwater Noise on the Marine Environment, in preparation (expected publication date June 2008).

European Union

- EU Parliament: 2004 Resolution B6-0018/2004 on the Environmental Effects of High-Intensity Active Naval Sonar.
- Guidelines for the Establishment of the Natura 2000 Network in the Marine Environment, 2007.
- EU Marine Strategy Directive, 2008.

The World Conservation Union (IUCN)

- IUCN Special Survival Commission (SSC) Cetacean Specialist Group “Action Plan for Dolphins”, 2003.
- Resolution 3.068 (2004) on “Underwater Noise Pollution”.

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