

Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds



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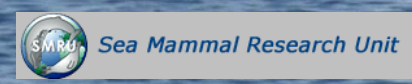


Photo taken under U.S. NMFS permit # 1121-1900



Behavioral Response Study 2007-08: *Sponsors and Participating Organizations*



SERDP
Strategic Environmental Research
and Development Program



Atlantic Undersea Testing and Evaluation Center: Jose Arteiro; Marc Cimonella; Tod Michaelis

Bahamas Marine Mammal Research Organization: Edward Adderley; Monica Arso; Diane Claridge; Charlotte Dunn; Kuame Finlayson; Leigh Hickmott; Alesha Naranjit; Olivia Patterson

Cornell University: David Brown; Christopher Clark; Ian Fein

Duke University: Ari Friedlaender; Douglas Nowacek; Elliot Hazen, Anna McGregor

Florida State University: Lou St. Laurent; Ken Decoteau; Eric Howarth

Marine Acoustics, Inc: Adam Frankel, Chuck Gagnon; *Clay Spikes**, Kathy Vigness, Kimberly Skrupky; Mark Wilson

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Naval Undersea Warfare Center NPT: Nancy DiMarzio; Susan Jarvis; David Moretti; Ron Morrissey; Jessica Ward

Sea Mammal Research Unit: Ian Boyd, Gordon Hastie; Nicola Quick

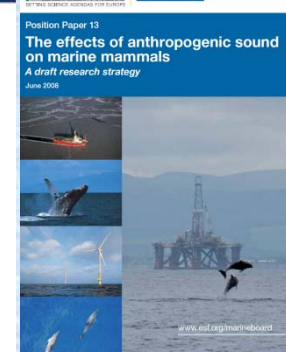
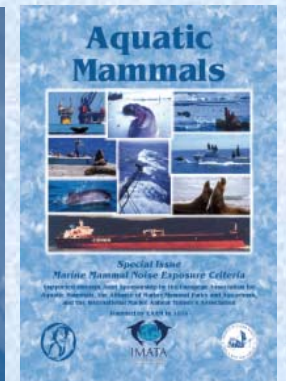
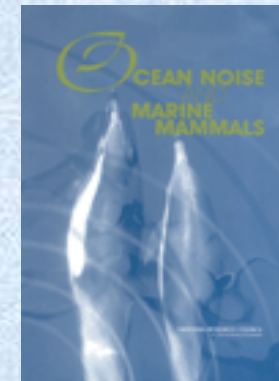
SPAWAR Systems Center, Pacific: *Angela D'Amico**; Rowena Carlson, Buddie Gilstrap; Chris Kyburg

Woods Hole Oceanographic Institution: Ann Allen, Marco Ballardini; Stacy DeRuiter; Nicolo' Gavazzi; Tom Hurst; Selena Klöti; Todd Pusser; Maria Elena Quero; Eletta Revelli; Stephanie Watwood; Matt Weingartner; Jeremy Winn; Becky Woodward; Alex Bocconceli; Walter Zimmer

University of La Laguna: Yara Bernaldo de Quirós

Overview - Marine Mammals and Sonar: Need for Directed Behavioral Response Measurements

- Strandings coincident with some sonar training exercises indicates strong negative reactions in certain species and circumstances
- Vast scientific uncertainty regarding these observations has led to widely divergent speculation on possible adverse impacts
- Numerous scientific and government panels/task forces have called for directed behavioral studies (*e.g.*, NRC 2000, 2003, 2004; Cox *et al.*, 2006; Southall *et al.*, 2007, 2009; Boyd *et al.*, 2008)



Behavioral Response Study 2007-08: *Goals*

- *Develop* safe experimental protocols for sound exposure
- *Obtain* direct measurements of responses to sonar and other sound exposure that indicate onset of behavioral disruption in different contexts
- *Compare* sensitivity of different species to different stimuli with controlled comparisons

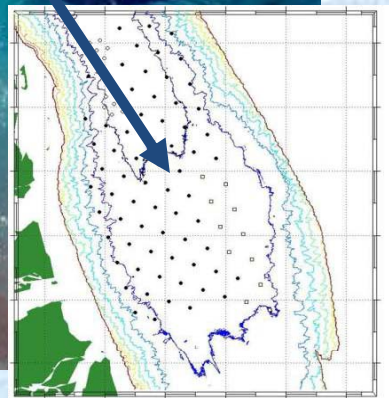
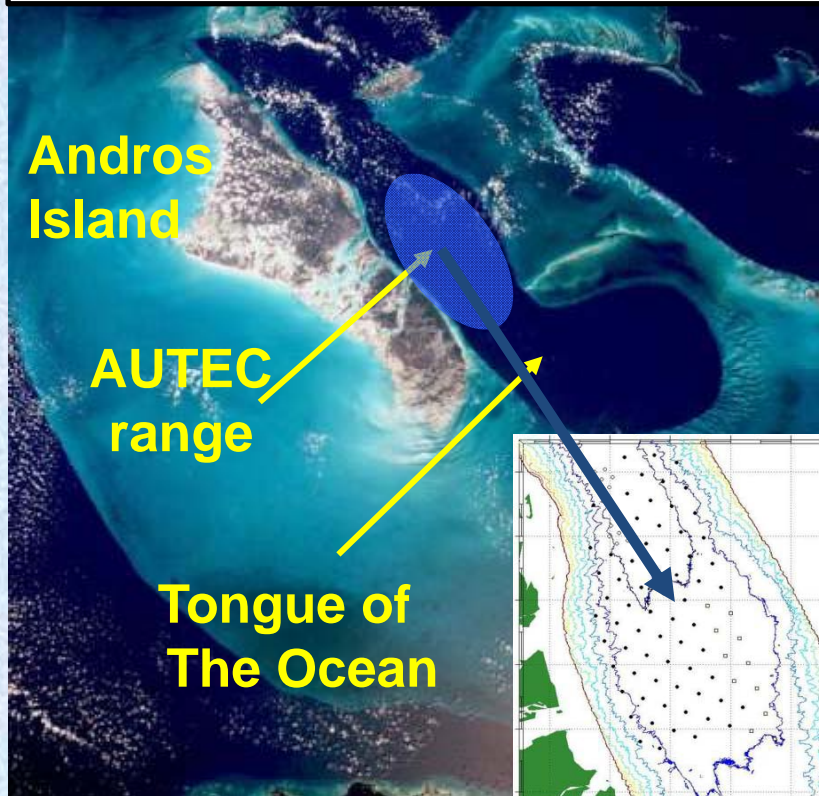
Provide a scientific basis for estimating risk and minimizing impact of sound to navies and regulators



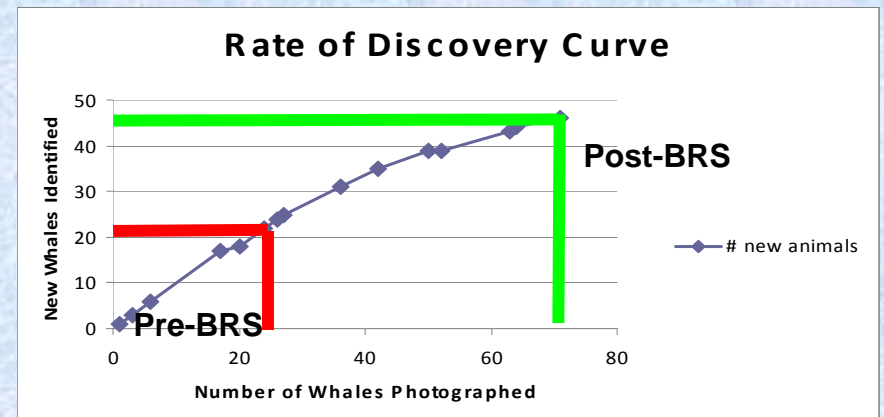


BRS-07/08 Field Site: *Tongue of the Ocean, Bahamas*

Critical Enablers: Real time passive acoustic monitoring over large area;
on-going marine mammal research and photo-ID



**82 hydrophones
~ 600 sq mi**



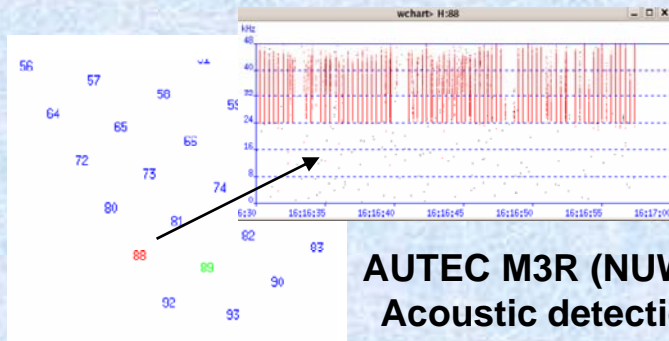
BRS-07/08 Deployments and Multidisciplinary Teams



2007: 14 Aug to 27 Sept using ATEC vessel *Ranger*; operating out of ATEC base



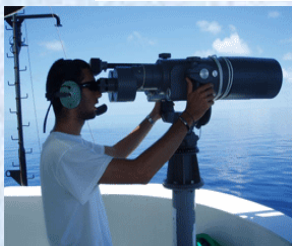
2008: 18 Aug to 2 Oct based aboard UNOLS R/V *Roger Revelle* (27 functional days available; 12 days evacuated due to weather)



**ATEC M3R (NUWC)
Acoustic detection**



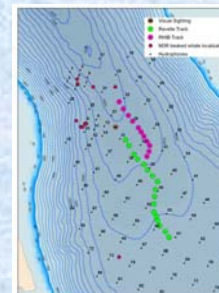
Source transmissions (NUWC (07); SSC-PAC (08))



Visual observations (Multi-national team)



DA Tagging and DTag data retrieval (WHOI)

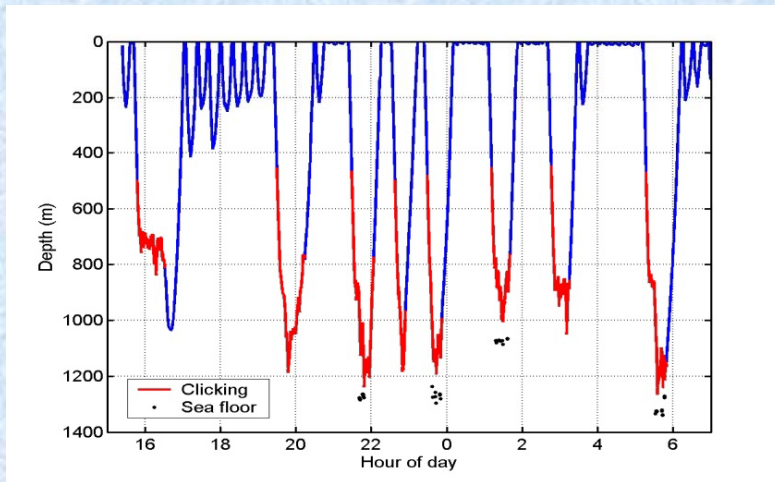


GIS & data mgmt (SSC-PAC)



Photo ID& Behavioral Observations (BMMRO)

BRS-07/08 Methodology: *Integration of Passive Acoustic and Visual Teams*



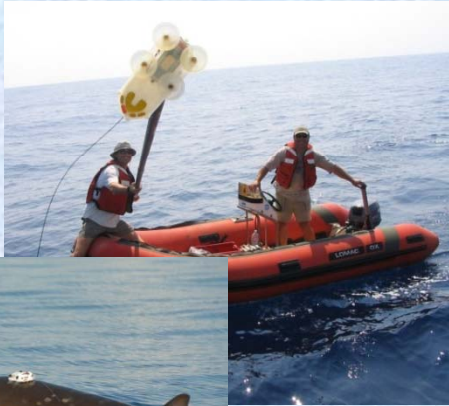
Video footage courtesy Cornell Laboratory of Ornathology (D. Brown and I. Fein);



Photo credit A. Friedlaender; taken under U.S. NMFS permit # 1121-1900



BRS-07/08 Methodology: *Tags and Tagging*



DTAGs measure:

- Dive
- Pitch and roll
- Acceleration
- Signatures for behavior
- Vocalizations
- Received sounds
- Fluke beat



Video footage courtesy Cornell Laboratory of Ornithology (D. Brown and I. Fein);
taken under U.S. NMFS permit # 1121-1900

BRS 07-08 Achievement Summary

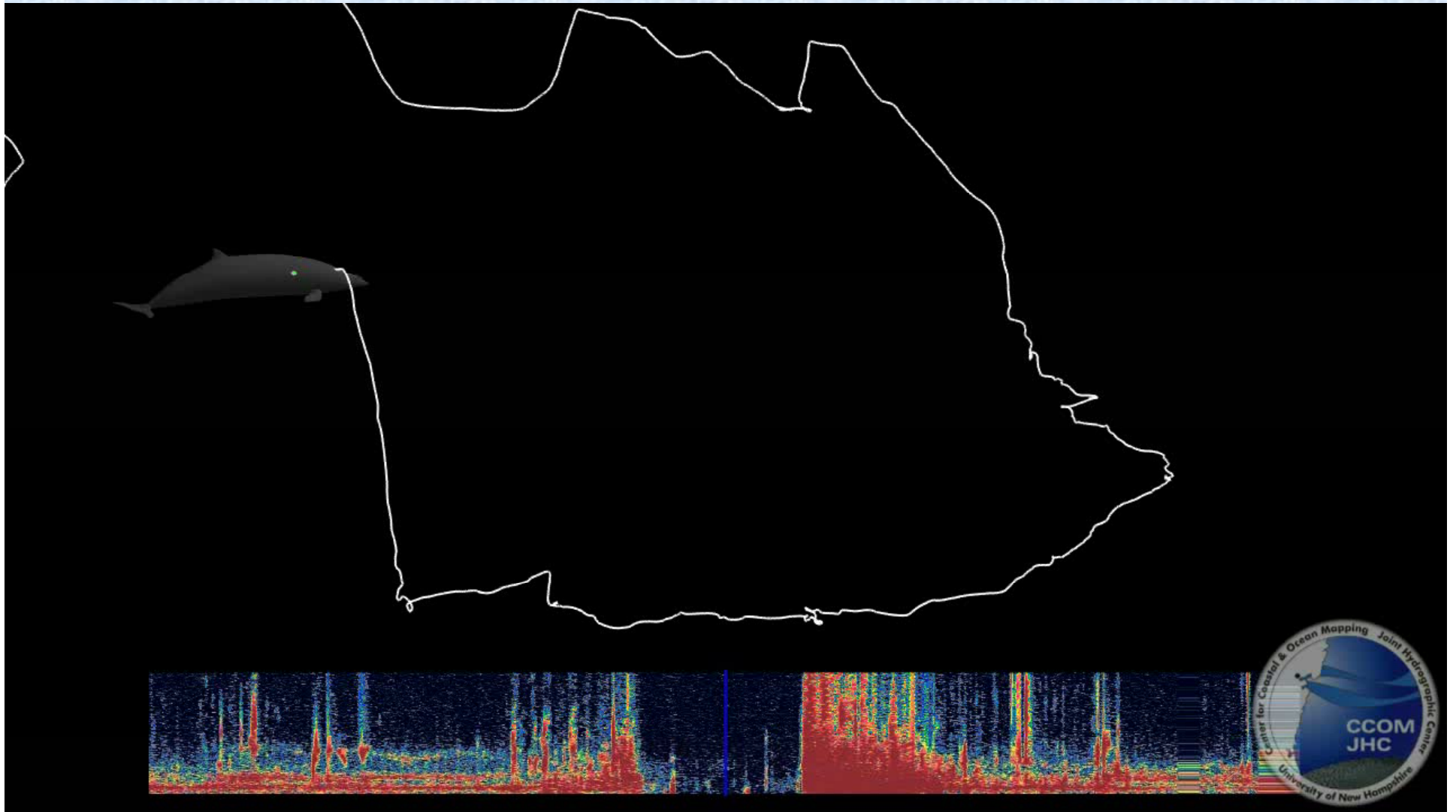


- **16 tags deployed on four species:** Blainville's beaked whale (7); pilot whale (6), false killer whale (2), and melon-headed whale (1)
[much baseline dive behavior, including for five beaked whales]
- **9 playbacks** of (some combination of) **MF sonar (3-4 kHz)**, **killer whale calls** (foraging-associated calls of transients) and **MF pseudo-random noise (PRN)** controls to: pilot whales (4), beaked whales (2), false killer whales (2) and a melon-headed whale (1)
- **Continuous passive monitoring** with AUTECH hydrophone array, including responses of untagged nearby animals to playbacks
- **16 vessel noise playbacks** (tracking responses on AUTECH hydrophone array)
- **Prey mapping** with active acoustics; **turbulence profiling**

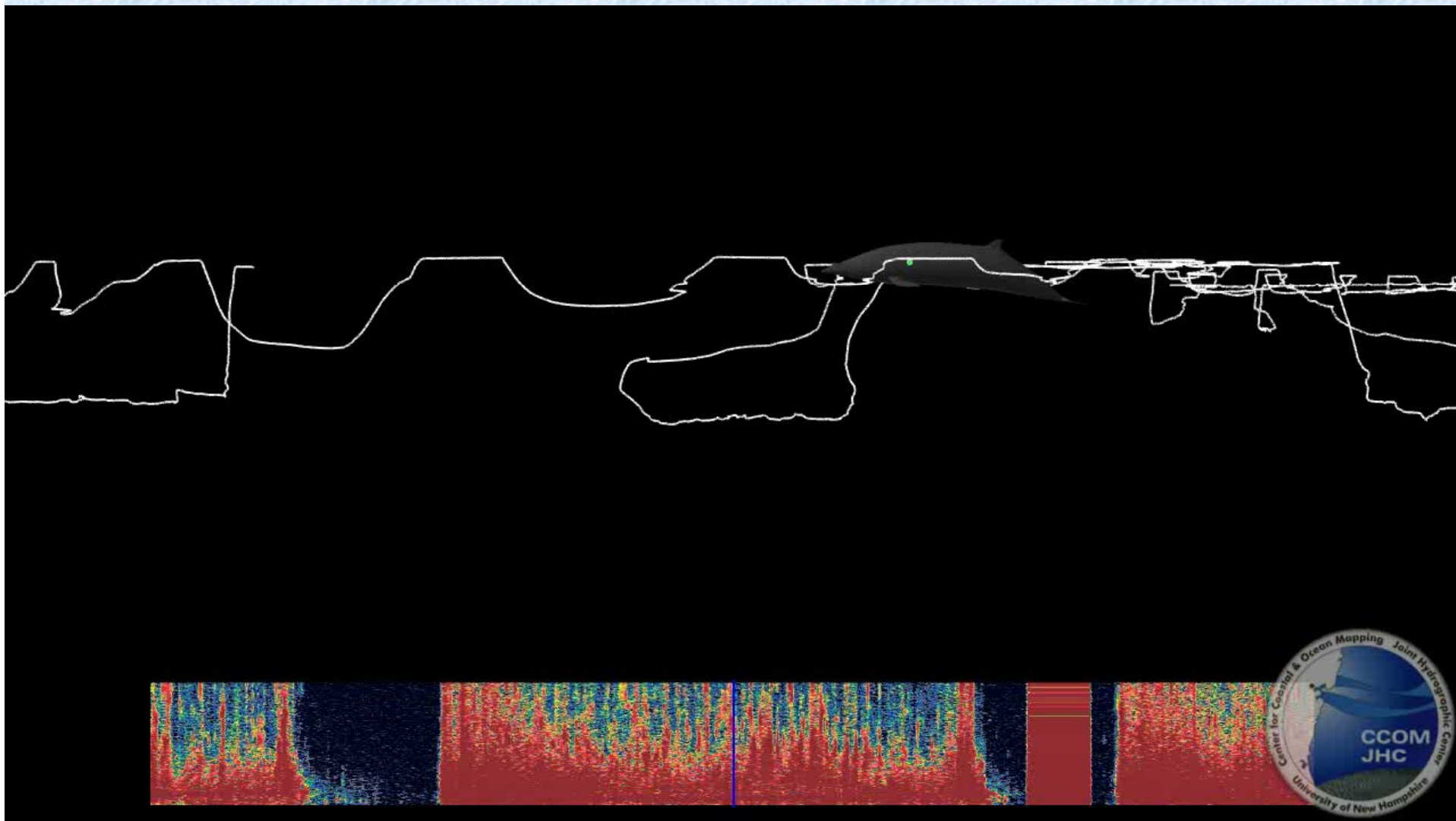


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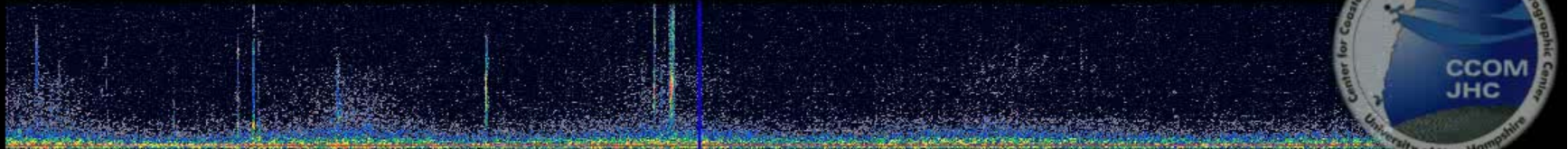
BRS-07 beaked whale CEE: *baseline dive*



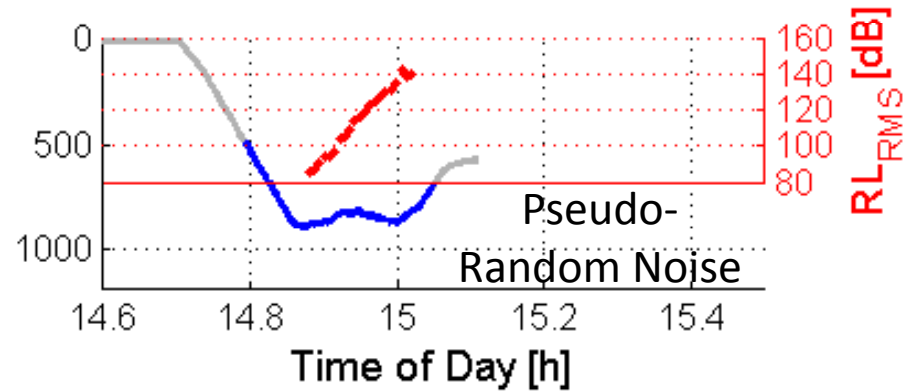
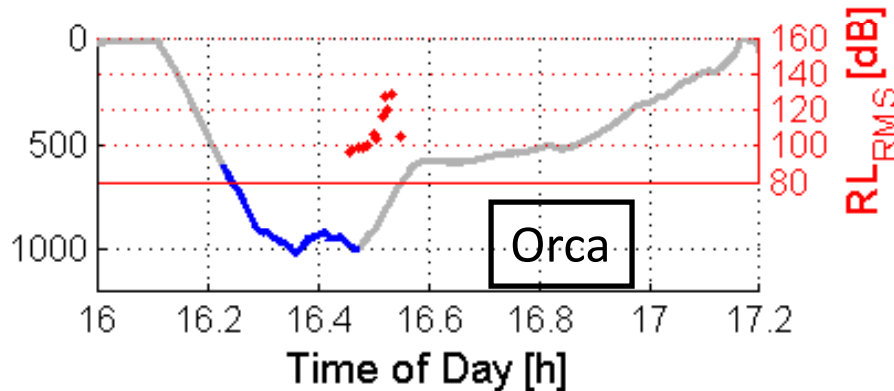
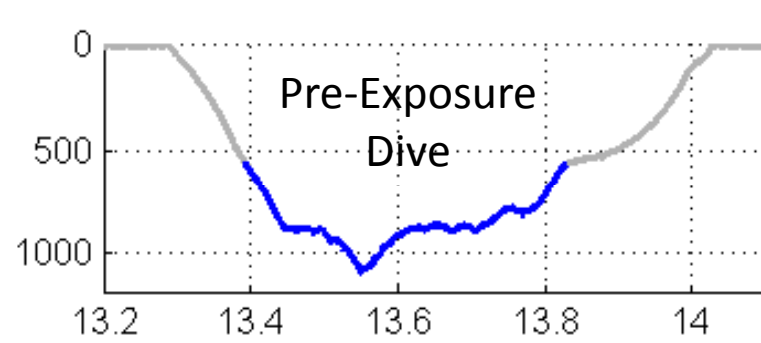
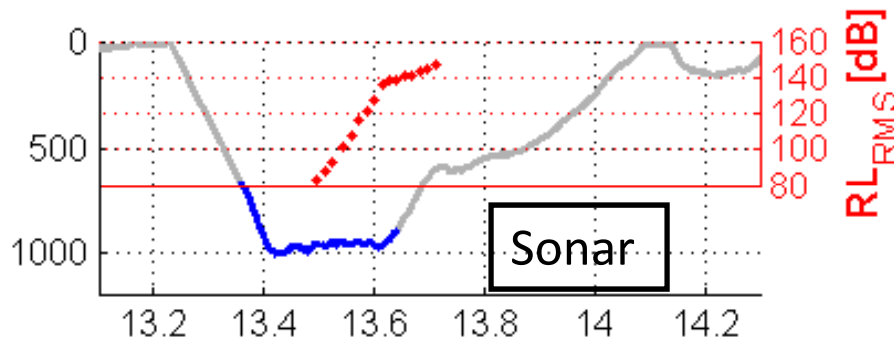
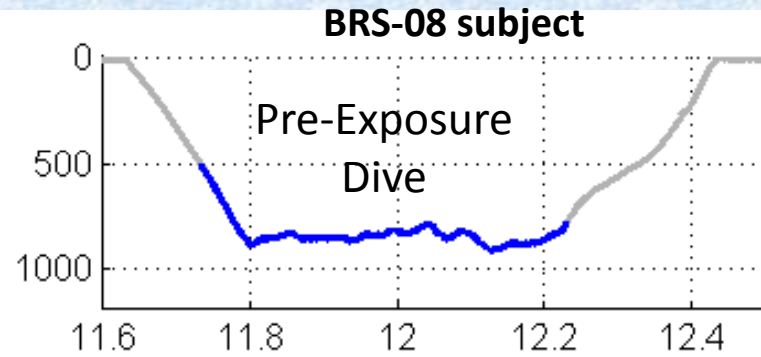
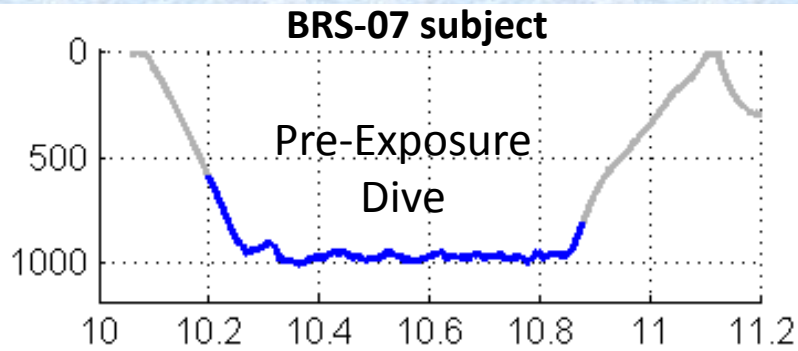
BRS-07 beaked whale CEE: *MF Sonar exposure*



BRS-07 beaked whale CEE: *Orca* exposure

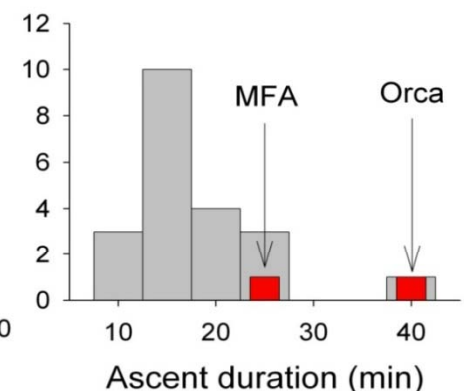
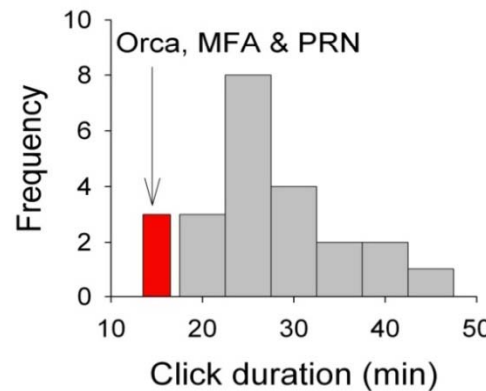
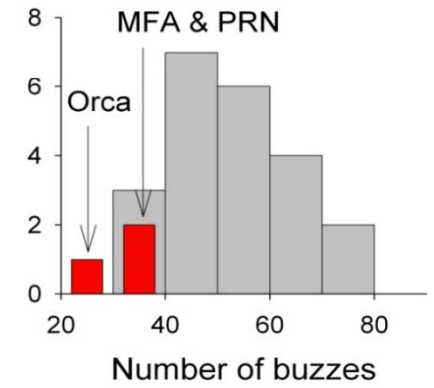
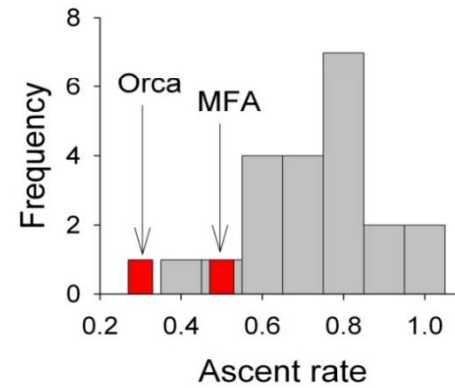


During CEEs, beaked whales stop clicking sooner and perform long, slow ascent



BRS 07-08 found a statistically significant response to playbacks in beaked whales

Dive Variable	Playback	Indiv	Sex
Click Dur	0.007	.075	0.048
# Buzz	0.001	0.17	0.44
Buzz Rate	0.46	0.41	0.45
Descent Rate	0.19	0.27	0.007
Descent Dur	0.08	0.07	0.003
Ascent Rate	0.005	0.48	0.155
Ascent Dur	0.005	0.068	0.01
Dive Dur	0.89	0.023	<0.001
Dive Depth	0.256	0.002	0.15

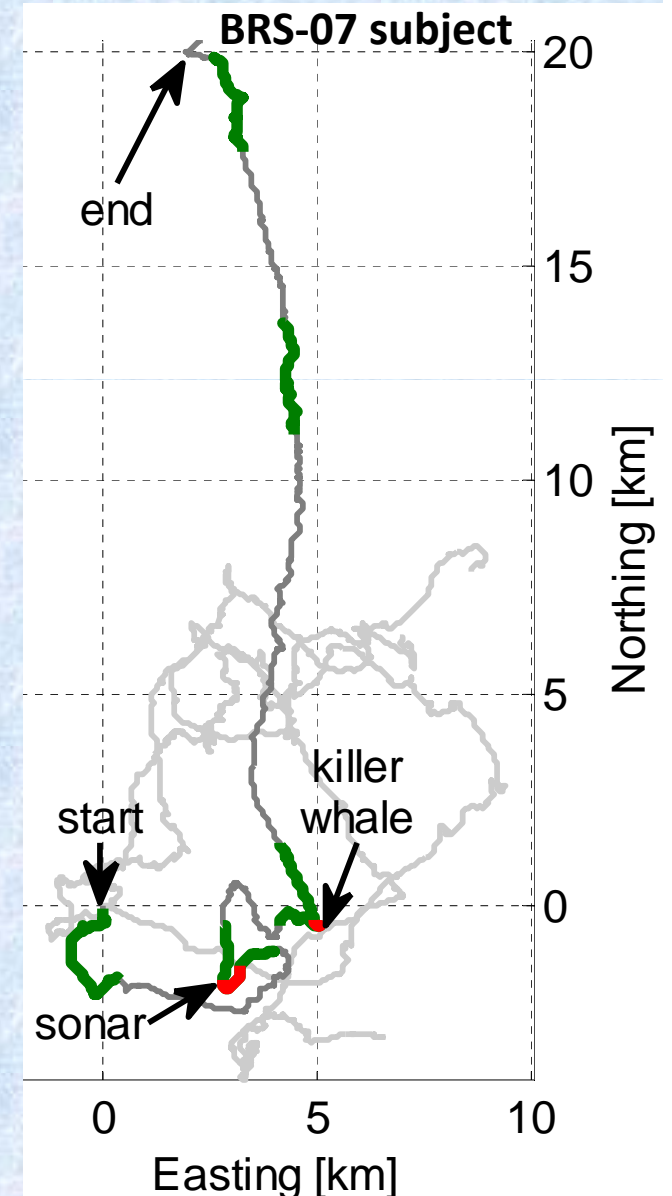


Statistical Analysis by Ian Boyd, SMRU

***Exposure Dives Stop Earlier,
With Slower Ascent than Normal Dives***

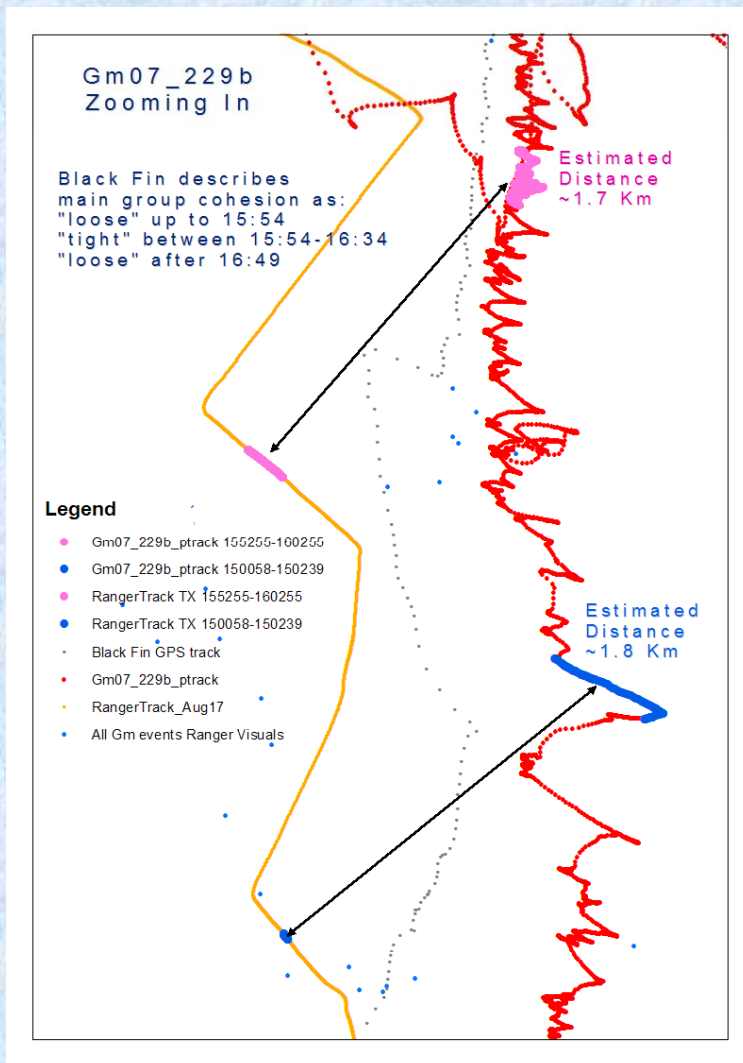
Beaked whale responses to sound exposure

Species	Stimulus	Received Level	Source
<i>Ziphius cavirostris</i>	Ship propulsion	136 dB re 1 μ Pa rms broadband	Aguilar et al. (2006) Marine Mammal Science, 22(3): 690–699
<i>Mesoplodon densirostris</i> 1	MFA	136 dB re 1 μ Pa rms broadband	BRS 07
<i>Mesoplodon densirostris</i> 1	Orca	102 dB re 1 μ Pa rms broadband	BRS 07
<i>Mesoplodon densirostris</i> 2	PRN	~140 dB re 1 μ Pa rms broadband	BRS 08





BRS Pilot Whale and False Killer Whale Playbacks



BRS-07

- Pilot whale (PW): no avoidance response to MFA or ORCA

BRS-08

- PW & False killer whale (FKW): no avoidance response to MFA or PRN
- FKW: whistle back to MFA

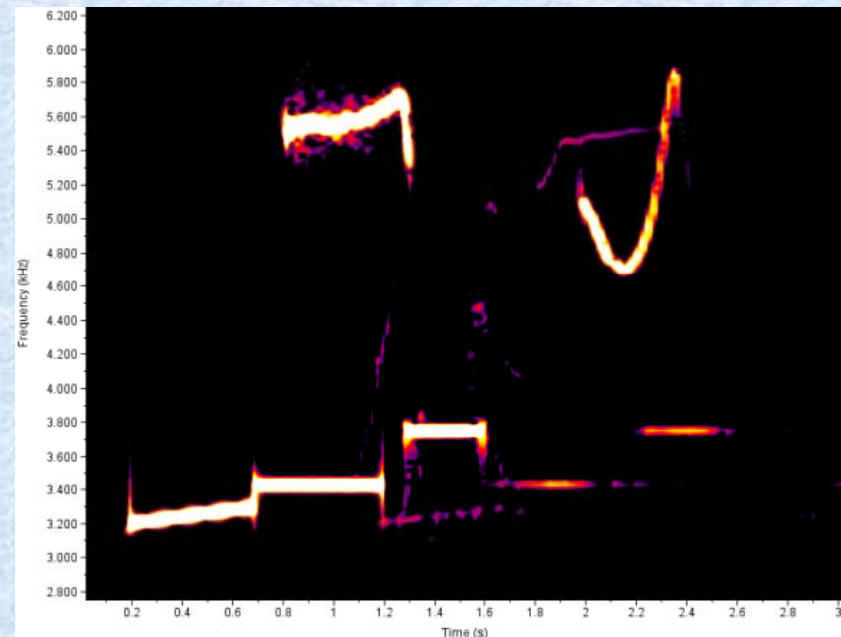


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Summary: Beaked vs. Pilot Whale Responses: *Anthropogenic Sounds and Killer Whale Calls*

Response Type	Beaked Whales	Pilot Whales
Dive	Premature Surfacing	No obvious change
Vocal	Premature Silencing	Variable, some cases with elevated whistle rate; some silencing, possible imitation of sonar (more so in FKW)
Approach/ Avoid	Prolonged Avoidance	Variable, some cases with short avoidance, some with none
Social Cohesion	Group splits	SubGroups Join



Overall Summary of BRS-07/08



- (1) BRS has developed a **safe method** to define exposure contexts inducing behavioral disruption in beaked and other whales
- (2) **Beaked whales showed consistent disruption of behavior** to each anthropogenic exposure **at considerably lower levels than pilot whales and delphinids.**
- (3) Beaked whale showed sustained avoidance following killer whale sounds; other species exhibited social defense responses. **Anti-predator behavior may be a risk factor for strandings.**
- (4) **Additional data** clearly needed, including with realistic sources and in areas where beaked whales hear less sonar.



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Other BRS talks/posters at SMM, Additional Information

Allen, Ann et al. "Analysis of a Blainville's beaked whale movement response to playback of orca calls"

[POSTER # 306: 1730-1900 on 13 and 15 October SUNDOWNER II sessions]

Hazen, Elliot et al. "Concurrent measurements of beaked whale clicks, physical oceanography, and prey fields in the Tongue of the Ocean, Bahamas"

[POSTER #566: 1730-1900 on 13 and 15 October SUNDOWNER II sessions]

Sayigh, Laela et al. "Stereotyped call sequences in short-finned pilot whales: evidence for individually specific and shared calls"

[PRESENTATION TIME: 1145 on WEDNESDAY 14 Oct in Room 200C]

DeRuiter, Stacy et al. "False killer whales mimic MFA sonar"

[PRESENTATION TIME: 0845 on FRIDAY 16 Oct in Room 200C]

Quick, Nicola, et al. "Vocal behavior of short-finned pilot whales pre, during and post exposure to playbacks of mid frequency active sonar and killer whale calls"

[PRESENTATION TIME: 0900 on FRIDAY 16 Oct in Room 200C]

BRS reports/video footage; noise criteria/JSOST report: www.sea-inc.net

BRS media: <http://aeinews.org/archives/310> ; <http://satellite.tmcnet.com/news/2009/08/11/4317481.htm>

MED-09 blog: <http://med09-expedition.blogspot.com/>

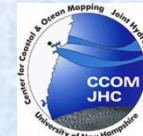


Acknowledgments

SPONSORS



PARTICIPANTS



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