

# Detrimental Decibels: The Effects of Naval Sonar and Seismic Activity on Cetaceans



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Blainville's beaked whale (*Mesoplodon densirostris*)



Gervais' beaked whale (*Mesoplodon europaeus*)



Cuvier's beaked whale (*Mesoplodon cavirostris*)





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Harbor Porpoise (*Phocoena phocoena*)



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Atlantic white-sided dolphin (*Lagenorhynchus acutus*)



Long-finned pilot whale (*Globicephala melas*)



Spinner dolphin (*Stenella longirostris*)



Risso's dolphin (*Grampus griseus*)





Melon-headed whale  
(*Peponocephala electra*)



Killer whale  
(*Orcinus orca*)



Guiana dolphin  
(*Sotalia guianensis*)



Northern bottlenose whale  
(*Hyperoodon ampullatus*)

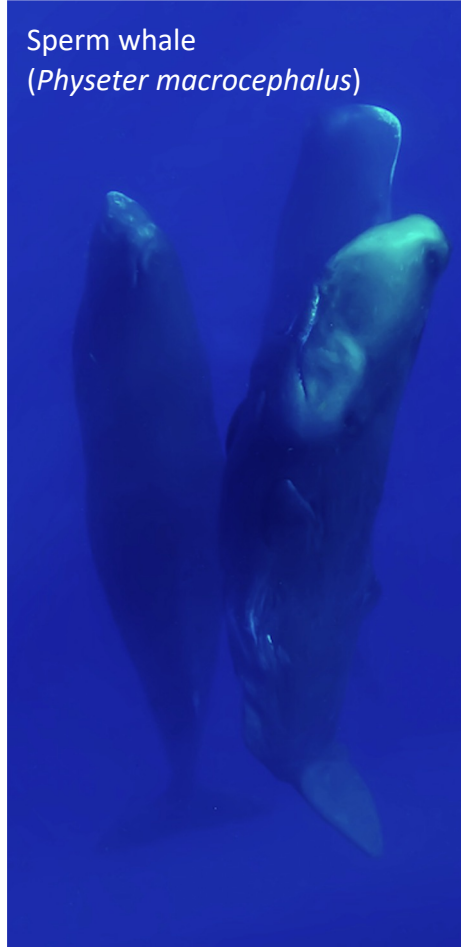
Minke whale  
(*Balaenoptera acutorostrata*)



Humpback whale  
(*Megaptera novaeangliae*)



Sperm whale  
(*Physeter macrocephalus*)



Blue whale (*Balaenoptera musculus*)



(Fontaine et al., 2022)



# Behavioral & Physical Impacts

- Feeding
- Directionality
- Strandings
- Energy
- Communication (physical & acoustic)
- Reproductive success
- Diving
- Bends
- Lesions/Hemorrhages to lung & ear tissue damage

(Henderson et al., 2016)



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# Measuring Probability

- Required under Marine Mammal Protection Act 1972 & Endangered Species Act 1973
- Simplicity
- Probabilistic dose (species specific)
- 2007- 280 dB
- Change in behavior at 135 dB for some species

(Harris et al., 2017)

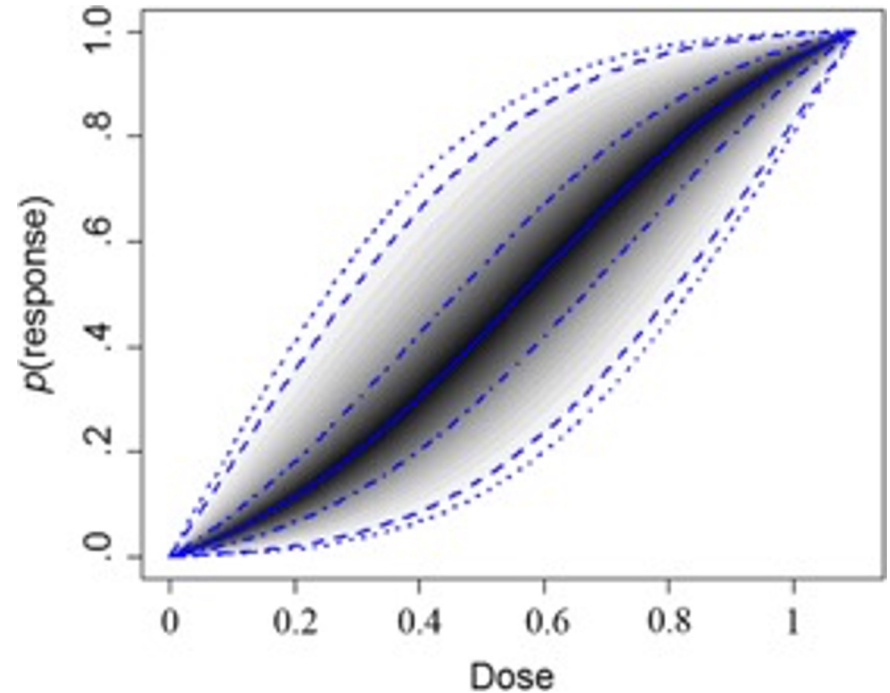












Figure 1: US Navy Sigmoidal dose used to measure the effects on cetacean species.



# Controlled Exposure Experiments (CEE) vs. Opportunistic Exposure Studies (OES)

- Control vs. treatment group
- Tagging

Table 1: Study procedures and equipment for CEE and OES.

	Visual observations	Animal-borne loggers (short-term, high-resolution acoustic tags)	Animal-borne loggers (medium to long-term satellite tags)	Animal-borne loggers (long-term satellite tags with GPS and acoustic recorders)	Passive acoustic monitoring
Controlled exposure experiments on <i>captive</i> animals					
Controlled exposure experiments on <i>free-ranging</i> animals					
Opportunistic exposure studies on <i>free-ranging</i> animals					

# CEE Beaked Whales Study 2007

- Cuvier's and Blainville's beaked whales
- >1000 m for > 1 hour
- \$5-6 million AUTECH in Abaco Island, Bahamas
- 3 day recovery time
- AN/SQS-56 or AN/SQS-53C mid-frequency active sonars (MFAS)
- Orca (Predator Response), MFA, and control

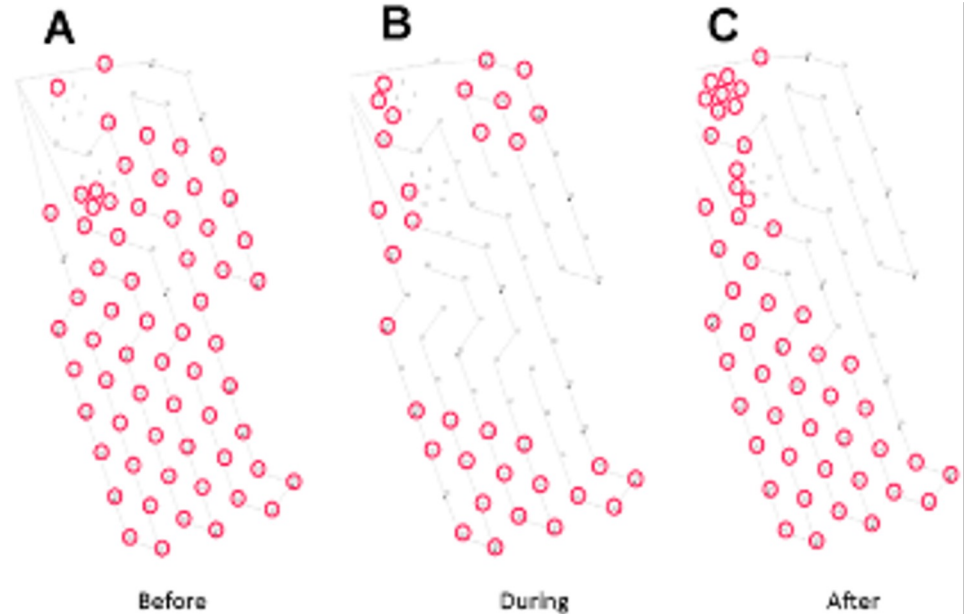


Figure 2: Distribution of beaked whales before, during, and after MFAS played.



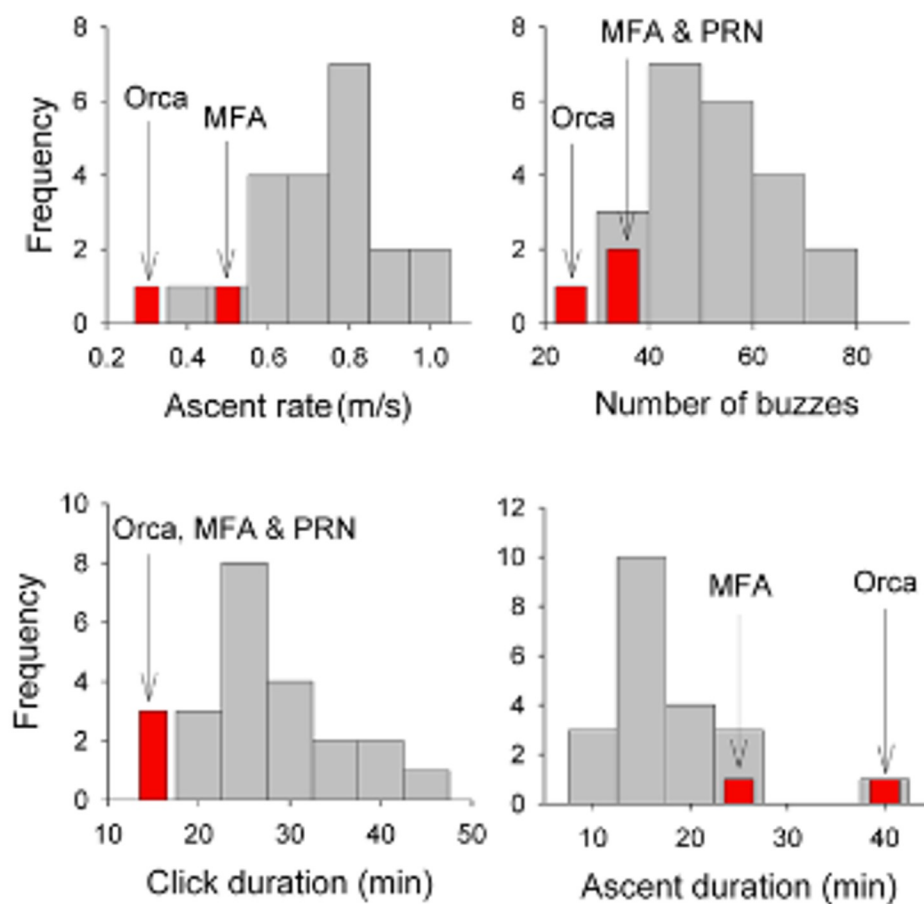


Figure 3: Graphs comparing the similarity of behavioral responses to the MFA and the Orca calls.

(Tyack et al., 2011)

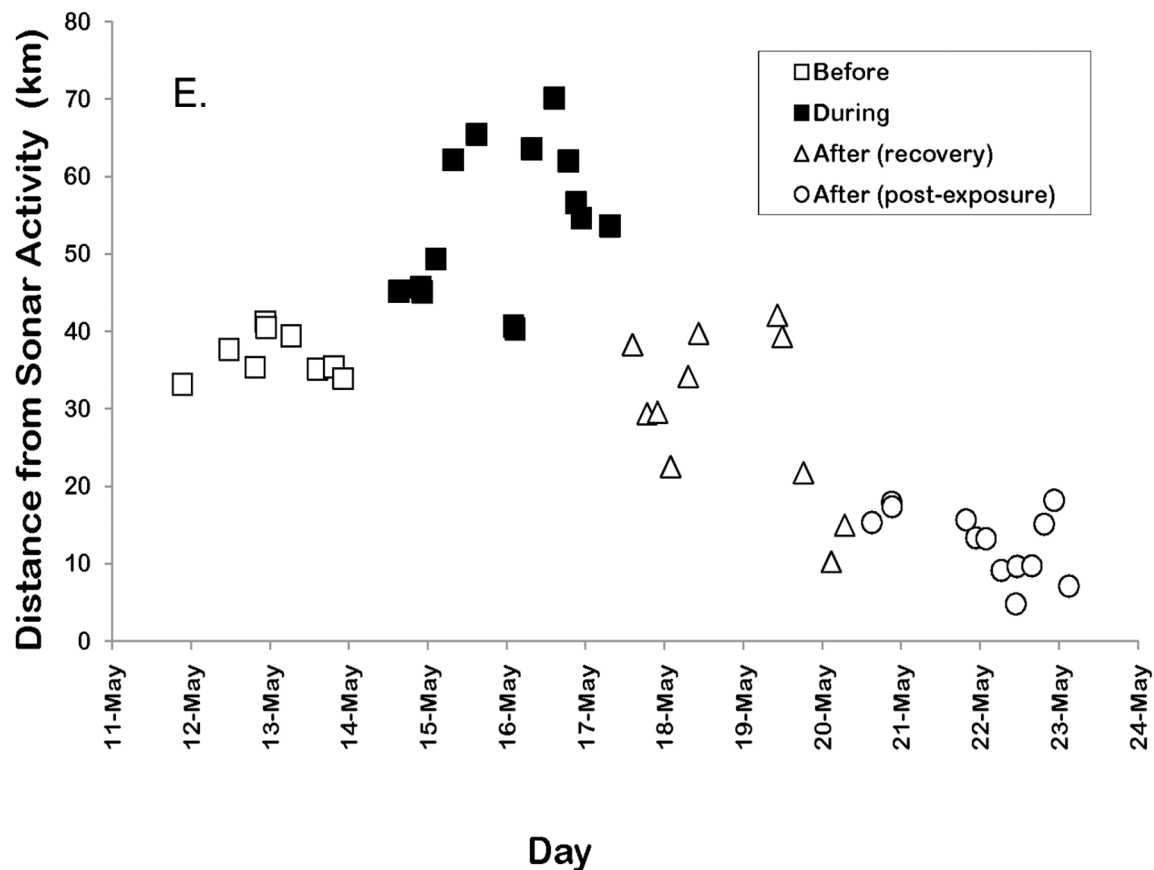


Figure 4: Longer term distribution of beaked whales before, during, and after experiment.



# Massive Cetacean Stranding March 2000

- 17 beaked whales, 2 minke whales, and 1 bottlenose dolphin
- Abaco Island, Bahamas
- 4 necropsied showing lesions & hemorrhages in around the ear bones & in the lungs
- Exposure to low frequency active sonars (LFAS)
- 150-180 dB
- Of the rescued Cuvier beaked whales, none were seen again
- “Acoustic Holocaust”



<https://www.thedodo.com/excerpt-war-of-the-whales-653512842.html>

# CEE Humpback, Minke, and Northern Bottlenose Whale Study

## Experiment:

- Norwegian Animal Research Authority
- Arctic Atlantic Ocean off of Bear Island (2011-2013)
- 11 Humpbacks, 1 Minke, 1 N. bottlenose whale (first study)

## Results:

- Avoided sound source (145-130 dB)
- Cessation of feeding
- Dive patterns (not Humpback)
- Cessation of communication
- Hours vs. days (experimental vs. real world)

(Sivle et al., 2015)

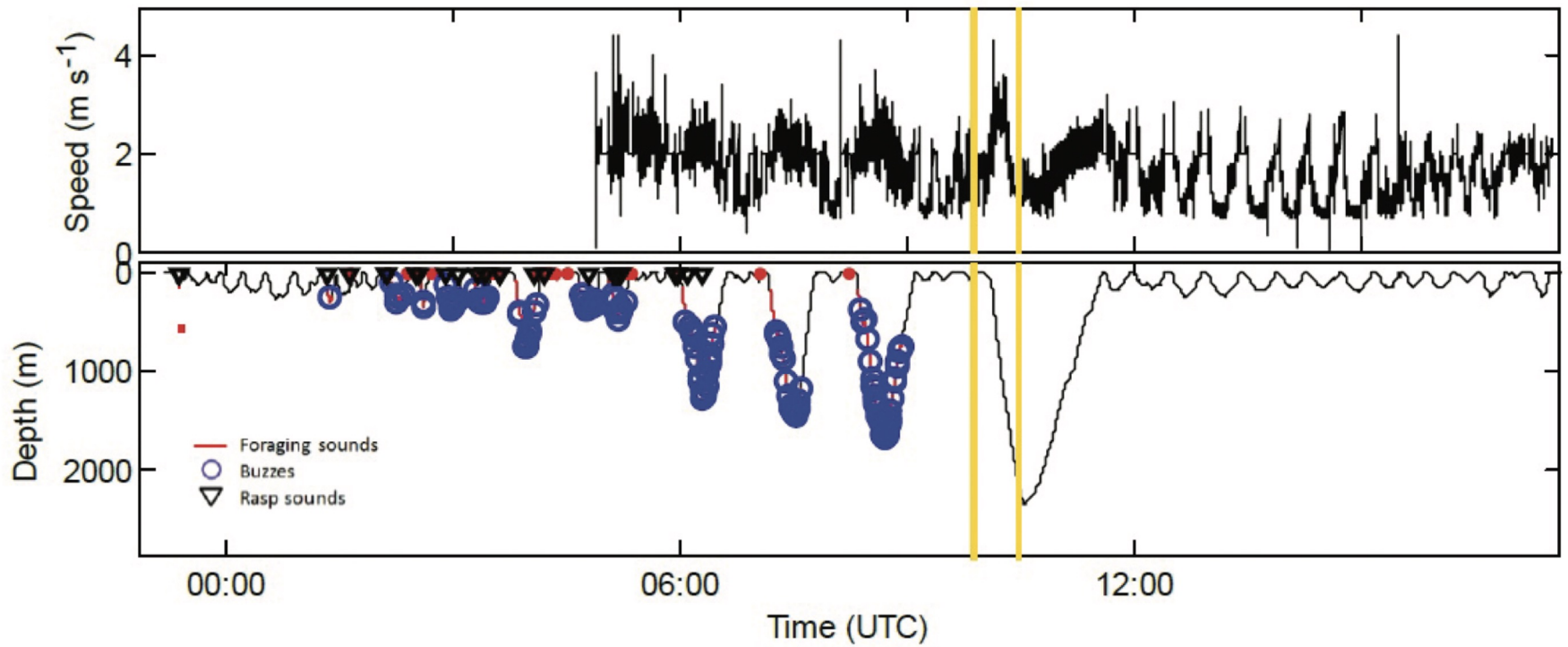


Figure 5: Graph that shows an unusual deep dive and inc. in speed from the N. bottlenose whale during the MFA. After this deep dive, the whale only dove short distances.



# CEE Killer, Long-finned Pilot, and Sperm Whale Study

- 2006, 2008, 2009 Northern Norway
- MFAS 209 dB, LFAS 152 dB, and control
- Cessation of feeding/resting/vocalization
- Avoidance, directional movement

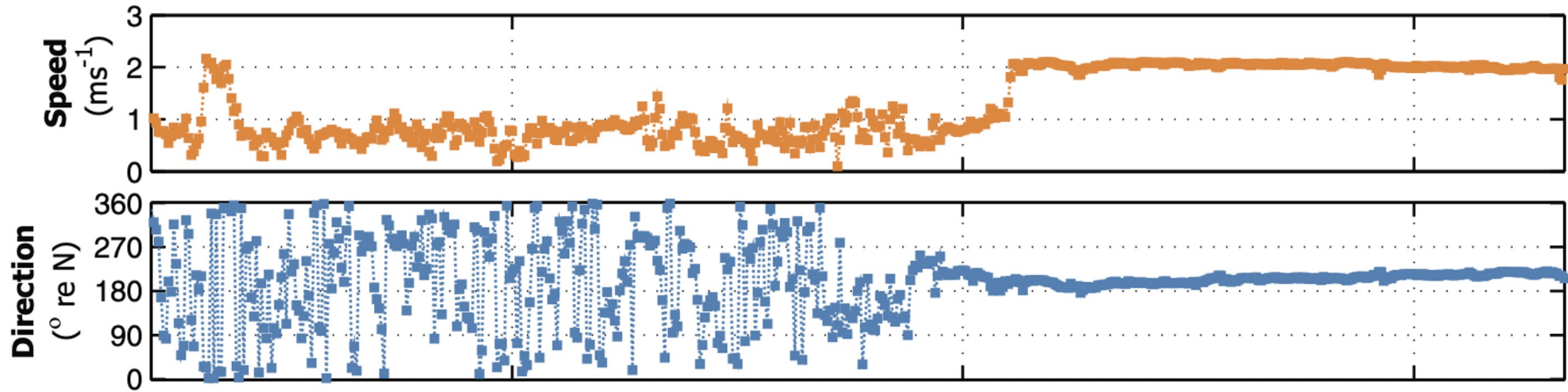


Figure 6: Change in speed and direction for Killer whales after MFAS started.

(Miller, 2012)

Table 2: The severity of the behavioral responses in cetaceans to MFAS and LFAS.

Score	Behavioral responses
0	<ul style="list-style-type: none"> <li>• No observable response</li> </ul>
1	<ul style="list-style-type: none"> <li>• Brief orientation response</li> </ul>
2	<ul style="list-style-type: none"> <li>• Moderate or multiple orientation responses</li> <li>• <i>Brief or minor changes in respiration rates</i></li> </ul>
3	<ul style="list-style-type: none"> <li>• <i>Prolonged orientation behavior</i></li> <li>• Minor change in locomotion (speed/direction) and or dive profile but no avoidance of sound source</li> <li>• Minor cessation/modification of vocal behavior</li> </ul>
4	<ul style="list-style-type: none"> <li>• Moderate change in locomotion (speed/direction) and or dive profile but no avoidance of sound source</li> <li>• <b>Brief avoidance of sound source</b></li> </ul>
5	<ul style="list-style-type: none"> <li>• Extended change in locomotion (speed/direction) and or dive profile but no avoidance of sound source</li> <li>• <b>Minor avoidance of sound source</b></li> </ul>
6	<ul style="list-style-type: none"> <li>• Moderate avoidance of sound source</li> <li>• Extended cessation or modification of vocal behavior</li> <li>• Visible startle response</li> <li>• <b>Moderate cessation of feeding</b></li> <li>• Prolonged shift in group distribution</li> </ul>
7	<ul style="list-style-type: none"> <li>• <b>Prolonged cessation of feeding</b></li> <li>• Moderate separation of female and dependent offspring</li> <li>• Severe and or sustained avoidance of sound source</li> </ul>
8	<ul style="list-style-type: none"> <li>• <i>Obvious aversion and/or progressive sensitization</i></li> <li>• <i>Long-term avoidance of area</i></li> </ul>
9	<ul style="list-style-type: none"> <li>• <i>Outright panic, flight, stampede, attack of conspecifics, or stranding event</i></li> </ul>

- Brief cessation/modification of vocal behavior

- *Individual alert behavior*
- *Moderate change of respiration rate*
- **Brief change in group distribution**

- Minor shift in group distribution
- Moderate cessation/modification of vocal behavior

- Moderate shift in group distribution
- *Change in inter-animal distance and/or group size*
- Prolonged cessation or modification of vocal behavior

- Brief or minor separation of female and dependent offspring
- *Aggressive behavior related to noise exposure*
- *Brief cessation of reproductive behavior*
- **Moderate cessation of resting behavior**

- *Extensive or prolonged aggressive behavior*
- *Clear anti-predator response*
- *Moderate cessation of reproductive behavior*

- Prolonged or significant separation of female and dependent offspring with disruption of acoustic reunion mechanisms
- *Prolonged cessation of reproductive behavior*
- *Avoidance related to predator detection*

(Miller, 2012)

# OES Humpback Seismic Survey Study

## Background:

- “Sing” in breeding areas July-Oct.
- Mouth of the Congo River in Angola
- Angola Liquefied Natural Gas (ALNG) plant
- 82% of hours studied had 2 or more “singers”

## Results:

- Seismic survey pulses in 449 hours in 50 days→ over half during breeding season
- Cessation in singing
- Other studies have shown an inc. in singing
- Negative effect



# Strandings



1985- Cuvier's and Gervais' beaked whales in the Canary Islands

1996- 12 Cuvier's beaked whales in Greece

2000- 17 beaked whales, 2 minke, and 1 dolphin in the Bahamas

2002- 14 beaked whales (all three mentioned species) in the Canary Islands

2003- 15 Harbor porpoises off the Strait of Juan de Fuca

2005- Long-finned pilot, minke, and dwarf sperm whale (*Kogia sima*) off of NC

2010- 14 Risso's dolphins in Peru & 60 Long-finned pilot whales in New Zealand

2014- 20 Long-finned pilot, 15 minke, 1 humpback, 1 orca, & 1 beluga whale in the UK

2018- 8 Stejneger's beaked whales (*Mesoplodon stejnegeri*) in Adak, AK



# Mass Stranding September 2020

- Macquarie Harbour,  
Tasmania
- Long-finned pilot whales
- 111/470 rescued
- Sept. 2022: 230 Long-  
finned pilot whales

(Guardian, 2022)



# Legislation

- 2008 Ocean Mammal Institute vs. Gates:
  - 12 mile exclusion zone,
  - monitors for marine mammals,
  - restricted helicopter sonar use,
  - shut down of MFAS when within 2,220 yards of cetaceans
  - reduce sonar power when in conditions that allows for sound to move farther.
- Navy argued “it could not effectively train if it had to shut down MFAS when marine mammals were within 2,200 yards.”
- With a 5-4 Supreme Court vote, George W. Bush enabled the Navy’s ability to continue the use the MFAS.



# Media Explanations

- “The most common cause of stranding is simply misadventure” - Kris Carlyon, wildlife biologist (Ryan, 2022)
- “The reason for whale stranding remains unknown but scientists believe pilot whales, which use echolocation to orient themselves, may become confused in shallower waters. They are highly social creatures, but this works against them.” - CNET (Ryan, 2022)
- “Hundreds of whales beached in Australia mass stranding, officials say at least half presumed alive” - Fox News (Sorace, 2022)



# Hope for the Future

- Inc. awareness
- Create global marine mammal hotspots
- More CEE & OES studies
- Change legislation
- Probabilistic dose for each species



# Questions?



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