Towards a Mysticete Audiogram Using Humpback Whale Behavioral Response Thresholds

Need

There is a need to improve understanding and measurement of auditory capabilities and sensitives of low-frequency cetaceans (mysticetes) to anthropogenic sound. Research necessary to generate a mysticete audiogram includes developing and validating finite element modeling (FEM) methods, developing and testing in-situ auditory evoked potential (AEP) measurement methods for mid- and high-frequency hearing sensitivities of mysticetes, developing tools for AEP measurements below 1 kHz, evaluating behavioral response methods, and identifying other appropriate approaches or methods.

Solution

This project addresses the portion of the need related to evaluating behavioral response methods for generating an audiogram. The project team, led by Dr. Rebecca Dunlop and Associate Professor Michael Noad, will measure the behavioral response of migrating humpback whales (*Megaptera novaeangliae*) to tones of various frequencies to infer their hearing sensitivity at each frequency. These behavioral response experiments will be a proxy for audiometric measurements to estimate hearing sensitivity.

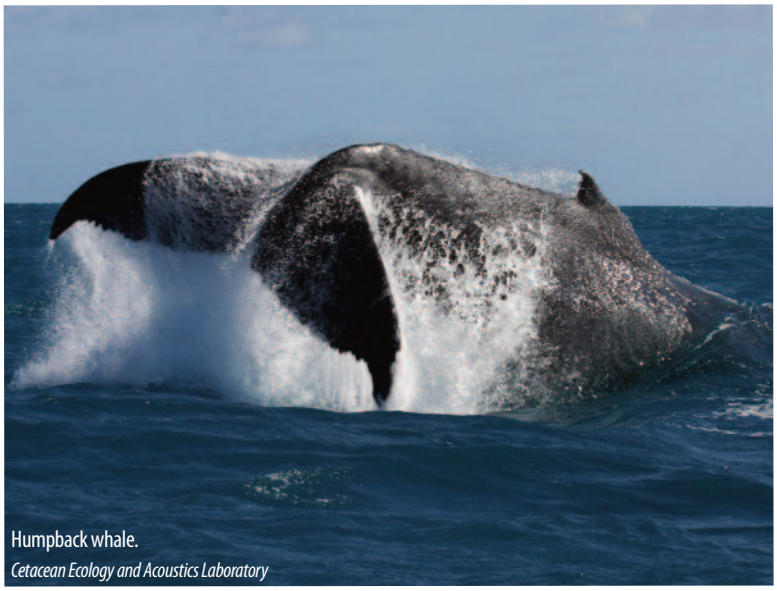
Methodology

A series of field experiments will be conducted in a unique site near Queensland, Australia. The field experiments will involve deploying a sound source from a vessel and playing upsweep tones at various frequencies (one frequency per treatment) to approaching whales. The source level of the tone will be held constant, but as the whales approach the sound source, the tones will become louder until the whales change behavior, likely by avoiding the source vessel. This will be repeated multiple times, using different whales, for each frequency. There will also be a similar number of trials in which the vessel will be present but no tones are transmitted to provide a control sample.

A four-phase experimental routine will be followed.

1. **Tagging phase**
   Attempt to tag an adult whale in the group.
2. **Before phase**
   Follow the group without interference to observe normal behavior and move the source vessel into position close to the projected path of the group.
3. **During phase**
   Operate the sound source as the group approaches until the signal is detected and the whale responds by avoiding the acoustic source/vessel.
4. **After phase**
   Conduct acoustic measurements and recover tags.

This experiment will require two small vessels (one for tagging and one for deploying the source) and two teams of land-based visual observers (one to visually follow the main group with the tagged whale and the other to identify other whales in the area that may affect the behavior of the main group). The researchers will also acoustically track singing whales that may affect the behavior of the main group using acoustic recorders deployed on the seafloor.



Humpback whale.
Cetacean Ecology and Acoustics Laboratory

The study site provides several benefits, including much lower noise levels than many ocean sites. The site's acoustic environment has been extensively measured and characterized. Eleven previous field seasons at this site provide a wealth of background data on whale movements, normal behaviors and abundance, which will support tagging efforts and facilitate detecting responses to the sound source.

Humpback whale.
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Schedule

The first of three consecutive annual field seasons will begin in 2021. Each field season will last five weeks. Results will be presented at professional conferences and manuscripts will be submitted for publication to peer-reviewed journals by the end of 2024.

Benefits

This project will provide new information on the hearing of humpback whales. The results of this project will include data on how well humpback whales can hear under ambient conditions, including data on masking of signals by noise. This will better enable regulators, industry and the U.S. Navy to model the potential effects of noise-producing activities on humpback whales. Results also will inform hearing models that have been developed for mysticetes, will help to validate and integrate the modelling approach with real data, and will provide a robust measure of humpback whale responses to tones under realistic conditions, which could be used in modeling the effects of various sound sources.

About the Principal Investigators

Rebecca Dunlop is a senior lecturer in physiology and animal behavior at the School of Veterinary Science, University of Queensland, Australia. Dr. Dunlop earned her Ph.D. in neuroethology from The Queen's University of Belfast, Ireland. Her current research focusses on humpback whale social communication, physiology, and the effects of anthropogenic noise.

Michael Noad is an associate professor at the School of Veterinary Science, University of Queensland, Australia. Dr. Noad earned his Ph.D. from the University of Sydney, Australia. His current work focusses on the evolution and function of humpback whale song, population ecology, and effects of noise.

BOEM Bureau of Ocean Energy Management

NOAA FISHERIES

Office of Naval Research ONR Science & Technology

MARINE MAMMAL COMMISSION

The Subcommittee on Ocean Science and Technology (SOST) authorized establishment of an Interagency Task Force on Ocean Noise and Marine Life (ITF-ONML). A subset of the ITF-ONML's member agencies partnered to jointly fund research on the auditory capabilities of mysticetes. This project is one of three projects that was selected for funding. Each project was funded by various agency partners.