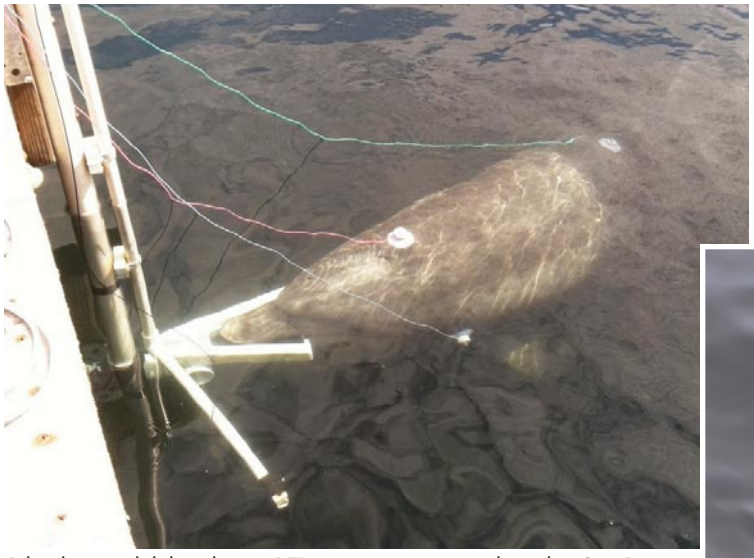
LIVING MARINE RESOURCES PROJECT 9

Electrophysiological Correlates of Subjective Loudness in Marine Mammals

THE NEED

The Navy is responsible for compliance with a suite of Federal environmental laws and regulations that apply to marine mammals and other marine protected species, including the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). As part of the regulatory compliance process associated with these Acts, the Navy is responsible for implementing a marine species monitoring program to assess potential impacts from Fleet and Systems Command (SYSCOM) military readiness activities involving active sonar and underwater detonations from explosives and explosive munitions. Potential impacts include exposure to marine mammals from sonar use or other underwater sounds. However, the level of impact associated with these sounds is difficult to determine without a thorough understanding of how these animals hear and the relative effects of sounds at different frequencies.

In humans, noise exposure is quantified by "weighting" sound exposures to emphasize frequencies where auditory sensitivity is high. The weighting functions are obtained from psychophysical tests where human listeners are asked to compare the perceived loudness of one sound to another sound at a different frequency. Although this approach has been successfully used with trained dolphins in a previous study sponsored by the Office of Naval Research (ONR), these tasks are very difficult to conduct with non-verbal animals. Most marine mammal studies have therefore relied on measuring reaction times to tones at various frequencies to estimate loudness and derive auditory weighting functions. Although much simpler than loudness comparison tasks, reaction time measurements still require access to trained animals for many weeks to collect the necessary data. This requirement limits the number of individuals and species for whom data can be obtained, forcing extrapolations to estimate weighting functions for untested species.



A bottlenose dolphin during AEP measurements conducted in San Diego Bay. The AEPs are measured using surface electrodes embedded in soft suction cups placed on the dolphin's head and dorsal surface.

THE SOLUTION

In contrast to psychophysical procedures that require highly trained subjects, hearing may also be assessed using electrophysiological measurements. These techniques use

non-invasive surface electrodes to measure small voltages (called auditory evoked potentials (AEP)) generated by the brain and auditory nervous system when an animal hears a sound. In contrast to psychophysical methods, AEP methods require no active participation from subjects, and data can be collected on animals for which access occurs opportunistically (e.g., stranded or rehabilitating whales). The AEP technique was developed by Principal Investigator Finneran under ONR funding. This LMR project will attempt to find a correlation between specific features of AEPs and perceived loudness. In this way, weighting functions could be estimated directly from AEP measurements, allowing more individuals/species to be directly tested.

THE METHODOLOGY

Previous studies have examined the feasibility of utilizing AEPs to predict perceived loudness in humans. In order to determine whether similar techniques can be used in dolphins and sea lions, a feasibility study will be conducted during which AEPs will be measured at a variety of sound frequencies and levels. The AEP data will then be analyzed to determine which, if any, features are correlated with loudness. If a suitable correlation is found, measurements will be expanded to include additional dolphins and sea lions.

THE SCHEDULE

The feasibility study is being conducted in 2013–2014. Testing in year 2 (2014–2015) will be contingent upon making satisfactory progress in identifying an AEP correlate for loudness during year 1. Data collection protocols would also be developed for opportunistic access to novel species (i.e., integrating the collection of loudness-correlated AEP data with the need to collect basic audiometric information from a stranded animal).

NAVY BENEFITS

The data resulting from this project will allow for more realistic, data-driven predictions of the effects of Navy sonars and explosive sources on marine mammals. The data would be applicable to all Navy environmental documents analyzing acoustic effects of tonal sounds (e.g., sonars) and broadband noise sources.

TRANSITION

The data and results of this study will be incorporated into Navy acoustic analyses, criteria and thresholds for at-sea compliance. Two peer-reviewed journal articles and two scientific conference presentations will also result from this study. These products will describe methods for estimating perceived loudness using electrophysiological methods and comparing weighting functions derived under a variety of test conditions.

ABOUT THE PRINCIPAL INVESTIGATOR

James Finneran has worked as a research scientist and mechanical engineer at the Space and Naval Warfare Systems Center Pacific since 2002, investigating marine mammal echolocation and marine animal auditory capabilities and studying the physiological effects of sound on marine animals. He has a Ph.D. in Mechanical Engineering from The Ohio State University.

About the LMR Program

The Living Marine Resources (LMR) program seeks to develop, demonstrate, and assess data and technology solutions to protect living marine resources by minimizing the environmental risks of Navy at-sea training and testing activities while preserving core Navy readiness capabilities. For more information, contact the LMR program manager at exwc_lmr_program@navy.mil or visit www.lmr.navy.mil.