LIVING MARINE RESOURCES PROJECT 47

Standardizing Auditory Evoked Potential Hearing Thresholds with Behavioral Hearing Thresholds

NEED

Auditory evoked potential (AEP) methods are often used to study hearing capability in marine mammals and have expanded the available audiogram data for both captive and stranded animals. AEPs will continue to be the primary means by which sample sizes of audiograms increase because they are easier to implement than behavioral hearing threshold methods, and they can be used in untrained or stranded animals. However, due to the frequency dependent elevation of AEP thresholds over behavioral hearing thresholds, AEPs are currently only used for defining species' upper frequency limit of hearing. Thus, the Navy currently uses only behavioral hearing thresholds for assessing absolute hearing sensitivity. The ability to study and account for the differences in the two methods might enable AEP audiograms to be adjusted and made comparable to audiograms obtained from behavioral audiogram approaches. The Navy would benefit from a standardized approach by which AEP hearing thresholds could be adjusted and compared to behavioral thresholds. This would make a greater number of AEP audiograms available for use in weighting function development and other Navy environmental compliance efforts, broadening the application of AEP results in future criteria development.

SOLUTION

This project will empirically determine relationships between behavioral hearing and AEP thresholds in small odontocetes to make behaviorally "equivalent" AEP audiograms. Although frequency-specific differences between behavioral and AEP audiograms have been previously explored in the bottlenose dolphin, a systematic evaluation of the differences between approaches has not been completed.

Bottlenose dolphin.

By measuring behavioral and AEP hearing thresholds in the same individuals across the range of hearing, the team will determine the frequency-dependent relationship between behavioral and AEP thresholds. Results will be applied to existing AEP audiograms to increase the data available for the development of auditory weighting functions and will allow AEP audiograms of untested small odontocetes to be converted to a form usable by the U.S. Navy in environmental compliance.

METHODOLOGY

The project team will study a subset of the bottlenose dolphins of the United States Navy Marine Mammal Program (MMP) that are trained for behavioral hearing tests and for participation in AEP studies. In Task 1, the team will focus on determining AEP threshold "equivalence" corrections for behavioral threshold prediction. Between four and ten bottlenose dolphins will be tested to determine the frequency-specific offsets between behavioral and AEP hearing thresholds. Each dolphin will perform an underwater behavioral hearing test for a specific frequency.

NAVFAC Naval Facilities Engineering Command ENGINEERING AND EXPEDITIONARY WARFARE CENTER

The collected behavioral threshold will become the "standard" for that frequency and for that day. After the behavioral threshold is established, AEP thresholds will be obtained in three different conditions: fully underwater, partially submerged and out of water ("beached"). The latter two test scenarios replicate the approaches commonly used with stranded and rehabilitating odontocetes. In-air testing will be limited to a subset of the dolphins that are tested underwater because fewer animals will be available for daily, voluntary beaching. In each condition the thresholds will be obtained with two sets of stimuli—repetitive tone-pips and sinusoidal amplitude modulated (SAM) tones.

Only one randomly selected frequency will be tested per animal per day and each day a different frequency will be selected from those prescribed for collection under ANSI/ASA S3/SC1.6. Across multiple days and spread over the course of a year, each frequency-specific threshold comparison will be replicated a minimum of four times. This will allow variability in the measurement for each test procedure to be characterized. Behavioral and AEP thresholds will subsequently be compared to determine frequency-specific corrections for AEP thresholds to bring the AEP audiograms in line with the behavioral audiogram.

In Task 2, the "equivalence" corrections derived from Task 1 will be applied to previously acquired AEP audiograms to produce behaviorally equivalent audiograms. Many audiograms, collected by varying methods and reflected in Task 1 testing, are available in the Cetacean Evoked Potential Audiometry Database (CEPAD). The team will apply the correction factors to audiograms of small odontocete within the CEPAD database, as well as to audiograms available from the open literature and others available but unpublished.

SCHEDULE

Behavioral and AEP testing and data analyses will begin in mid-2021 and be conducted over approximately 21 months. Existing audiograms will be collected and equivalence audiograms generated during the second year of the project. The team will provide regular reports to LMR throughout the project and expects to complete a manuscript discussing results of the behavioral and AEP comparisons early in the project's third year.

Bottlenose dolphin.

NAVY BENEFITS

The U.S. Navy utilizes an audiogram-based approach to the prediction of marine mammal auditory weighting functions. Unfortunately, there are a limited number of species for which behavioral audiograms exist, and those are based on only one to a few individuals available for most species. Behaviorally equivalent AEP audiograms will substantially increase the data available for the development of auditory weighting functions and will allow AEP audiograms of untested small odontocetes to be corrected to a form the Navy will be able to use in its environmental compliance efforts.

TRANSITION

Results of the behavioral and AEP test comparisons from Task 1 will be published in the peer-reviewed scientific literature. The behaviorally equivalent AEP audiograms developed under Task 2 will be published as a U.S. Navy Technical Report and provided to Navy personnel. The equivalent audiograms should bolster weighting function design and add defensibility to the approach by increasing the numbers of audiograms and species' representations.

ABOUT THE PRINCIPAL INVESTIGATOR

Dorian Houser is the Director of Biologic and Bioacoustic Research at the National Marine Mammal Foundation (NMMF). He has spent nearly two decades in the study of how anthropogenic sound affects marine mammals and serves as the chair of an American National Standards Institute/Acoustical Society of America (ANSI/ASA) committee on animal bioacoustics. Dr. Houser chaired the working group that led the development of the standard ANSI/ASA S3/SC1.6 2018, *Procedure for Determining Audiograms in Toothed Whales through Evoked Potential Methods.* He earned his Ph.D. in biology from the University of California, Santa Cruz.

Co-PIs: Dr. Jason Mulsow (NMMF) and Dr. James Finneran (U.S. Navy Marine Mammal Program).

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.navfac.navy.mil/lmr.