



## LIVING MARINE RESOURCES PROJECT 39

# Use of “Chirp” Stimuli for Non-invasive, Low-frequency Measurement of Marine Mammal Auditory Evoked Potentials

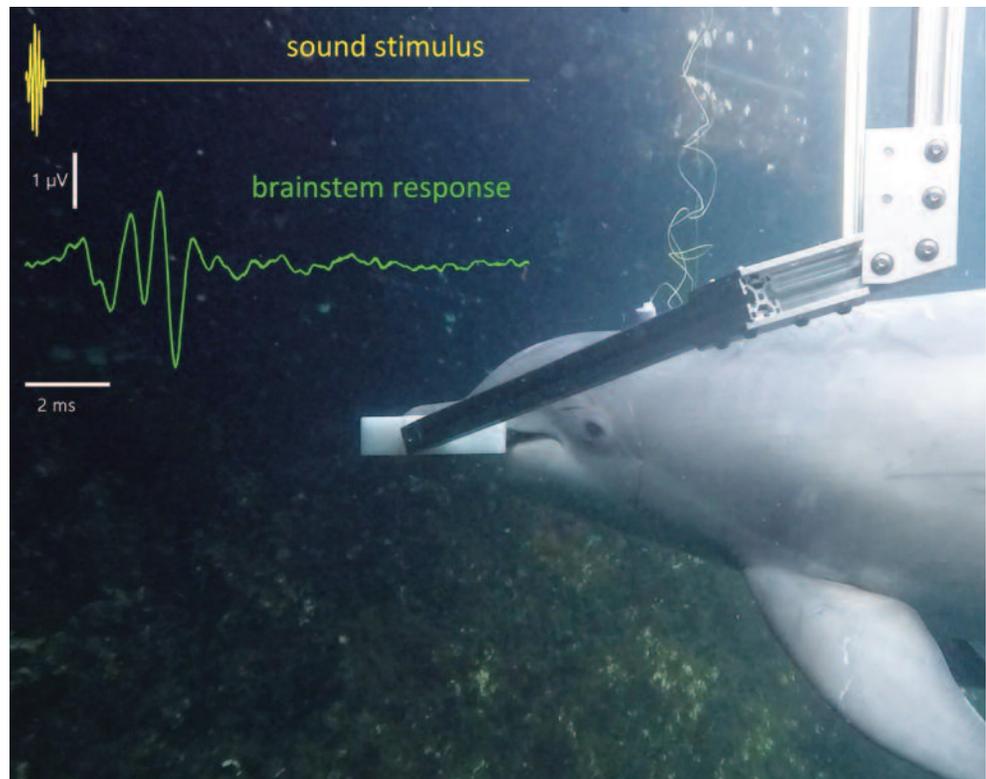
### NEED

The Navy needs information to improve understanding and measurement of auditory capabilities and sensitivities of low-frequency cetaceans (mysticetes) to anthropogenic sound. Research needed to generate mysticete audiograms include 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 is focusing on one of the methods noted in the Need section—examining potential tools to inform AEP measurements below 1 kHz in mysticetes. AEP methods involve measuring small voltages that the brain and auditory nervous system generate in response to sound and are measured and used to evaluate auditory capabilities. The goal of this project is to determine the extent to which an upward “chirp” stimulus—a sound whose

frequency increases with time—can increase AEP amplitudes at lower frequencies in marine mammals. The chirp stimuli will be specially designed so that the rate at which the frequency sweeps upward optimally matches the (species-specific) properties of the inner ear. Experimentally determined properties of the “optimal” chirp will then be compared with anatomical properties of the inner ear, which could support predicting optimal chirp for other species, such as mysticetes, for which only anatomical data exist.



A bottlenose dolphin positioned on a “biteplate” during an AEP measurement. AEPs are measured using human EEG electrodes embedded in suction cups and placed on the head (an electrode is visible just behind the dolphin’s blowhole). Short duration sound stimuli are presented using an underwater sound projector in front of the dolphin. The EEG signal is then averaged to reveal the auditory brainstem response, a type of AEP occurring within the first 10 ms following a sound.

*NIWC Pacific (Distribution A)*

## METHODOLOGY

The project has three broad objectives:

1. Determine the extent to which **broadband** upward chirps increase AEP amplitudes and how the effectiveness of a broadband chirp varies with chirp sweep rate, duration, frequency range and level.
2. Determine the extent to which **narrowband** upward chirps increase AEP amplitudes compared to tone burst stimuli and if narrowband chirps provide advantages (compared to tone bursts) for marine mammal auditory threshold testing.
3. Determine if optimal chirp properties can be predicted from cochlear traveling wave speed (TWS) estimates and/or anatomical measurements of the cochlea.

Data will be collected with bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*). These species are available at the US Navy Marine Mammal Program and they represent echolocating cetaceans with good high-frequency (10–100 kHz) hearing and marine carnivores with good mid-frequency (1–10 kHz) hearing. Sea lions provide a means of approximating the frequency range of hearing expected for some mysticetes while testing a more accessible species.

## SCHEDULE

The first year of this two-year project will focus on measuring AEPs to broadband stimuli and estimating cochlear TWS and optimal chirp properties from derived band AEP data. Narrowband stimuli will be the focus in year two. Interim and final manuscripts on results will be completed in years one and two, respectively.

## NAVY BENEFITS

The data collected from this effort will contribute to developing tools needed to advance AEP measurements below 1 kHz. Given the anticipated difficulty in measuring AEPs in mysticetes, technical innovations that result in increased AEP amplitude (and thus improve AEP detectability) will be of great benefit to directly obtaining information on hearing in mysticetes.

## TRANSITION

Data resulting from this project will be presented at scientific conferences, published in peer-reviewed scientific journals, technical reports and/or white papers and will be disseminated to Navy environmental planners. Methods and processes for enhancing low-frequency AEP amplitude could then be incorporated into efforts to directly measure AEPs in mysticetes (or other marine mammals).

## ABOUT THE PRINCIPAL INVESTIGATOR

James Finneran has worked as a research scientist at the Naval Information Warfare Center (NIWC) Pacific since 2002, investigating marine mammal echolocation and marine animal auditory capabilities and studying the physiological effects of sound on marine animals. Dr. Finneran earned his Ph.D. in Mechanical Engineering from The Ohio State University.



Key contributors include Dr. Jason Mulsow from the National Marine Mammal Foundation and Dr. Robert F. Burkard from the University at Buffalo.

## 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](mailto:exwc_lmr_program@navy.mil) or visit [www.navfac.navy.mil/lmr](http://www.navfac.navy.mil/lmr).

