



## LIVING MARINE RESOURCES PROJECT 24

# Frequency-dependent Growth and Recovery of TTS in Bottlenose Dolphins

### NEED

Navy at-sea training activities must comply with a suite of Federal environmental laws and regulations, including the National Environmental Policy Act (NEPA), Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA). As part of the regulatory compliance process associated with these acts, the Navy needs data on potential hearing effects from military readiness activities involving active sonar and underwater detonations from explosives and explosive munitions. However, the level of effect associated with these sounds is difficult to determine without a thorough understanding of the relative effects of sounds at different frequencies.

Hearing sensitivity can decrease (i.e., hearing thresholds can increase) after exposure to noise, depending on factors such as the intensity, duration, duty cycle and frequency of the sound. If hearing thresholds recover to pre-exposure levels after some time, the change in sensitivity is known as a temporary threshold shift (TTS). If thresholds do not recover, the change from pre-exposure levels is a permanent threshold shift (PTS). Navy acoustic impact analyses currently used in the permitting process apply auditory weighting functions, similar to those used in assessing risk to human hearing, to predict the occurrence of TTS and PTS as functions of frequency. Weighting functions are mathematical functions that emphasize, or “weight,” noise at different frequencies according to the listener’s susceptibility to noise at that frequency.

Direct measurements of TTS in representative marine mammal species—across a broad spectrum of sound frequencies—are needed to support the TTS/PTS thresholds and weighting function derivations. In addition, discrepancies between behavioral and auditory evoked potential (AEP) measures of TTS have prevented AEP-based TTS data from being directly used to develop TTS/PTS thresholds, effectively limiting the number of species/frequencies represented in the underlying data.



Bottlenose dolphins.

Mark H. Deakos, permit 14451

### SOLUTION

The objectives of this effort are to (1) determine exposure levels corresponding to the onset of TTS across a broad range of frequencies in bottlenose dolphins (*Tursiops truncatus*) with full hearing bandwidth (up to frequencies of about 140 to 160 kHz), (2) develop TTS recovery models for use in acoustic

impact assessments, and (3) examine the relationship between TTS measured using behavioral methods and auditory evoked potential methods.

## METHODOLOGY

Hearing thresholds in bottlenose dolphins not previously represented in TTS onset studies will be measured using both behavioral and electrophysiological (AEP) methods. After baseline hearing thresholds have been determined, TTS testing will begin. Hearing thresholds will be measured before and after exposure to a fatiguing noise and then compared to determine any threshold shift occurrences. After any measureable shift, post-exposure testing will continue up to several hours as needed to track recovery and to determine that no PTS has occurred. Subject health, welfare and behavior will be continuously monitored and managed by attending veterinarians and animal care staff at the Space and Naval Warfare Systems Center Pacific.

## SCHEDULE

Data collection will begin in early 2017. Initial TTS onset results are anticipated in early 2018 and the bulk of data collection will be completed by the summer of 2019. Publications will be completed soon after.

## NAVY BENEFITS

Navy acoustic impact criteria use auditory weighting functions to predict the onset of TTS and PTS as functions of sound frequency. The data resulting from the proposed effort will be used to define the Navy Phase IV weighting function and TTS/PTS threshold values for the mid-frequency cetacean group, validate

the extrapolation procedures used to derive weighting functions and TTS/PTS thresholds for other species groups, develop practical models for recovery from TTS, and enable broad comparisons between behavioral- and AEP-based measures of TTS. The data will be directly applicable to all Navy environmental documents analyzing acoustic effects of tonal sounds (e.g., sonars) and broadband noise sources and could be used in extrapolations for criteria/thresholds for impulse sources.

## TRANSITION

The primary avenue for distributing project results will be one or more peer-reviewed journal articles that describe TTS as a function of exposure frequency. Two conference presentations also are planned, in which preliminary results will be presented. Recipients will include the Navy environmental community, producers and regulators of underwater sound (e.g., National Marine Fisheries Service, Bureau of Ocean Energy Management), and the general scientific community.

## ABOUT THE PRINCIPAL INVESTIGATOR

James Finneran has worked as a research scientist 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](mailto:exwc_lmr_program@navy.mil) or visit [www.lmr.navy.mil](http://www.lmr.navy.mil).

