



LIVING MARINE RESOURCES PROJECT 79

Investigation of Temporary Threshold Shifts in Sea Turtles to Support Navy Compliance Permits

NEED

The Navy needs data on potential impacts to marine species from Navy training and testing activities. Identifying and measuring the potential effects of sound from such activities supports Navy acoustic threshold criteria. Recent underwater hearing studies indicate that freshwater and sea turtles can detect low-frequency sounds, and freshwater turtles can incur noise-induced hearing threshold shifts. These results suggest concern for similar auditory impacts for sea turtles from U.S. Naval activities such as underwater explosions, pile driving and low-frequency active sonar. The lack of empirical data on acoustic impacts to sea turtles limits the ability to quantify or mitigate these effects.

SOLUTION

This project is measuring underwater temporary auditory threshold shifts in two sea turtle species. The project team will evaluate and refine methods used to test sea turtle hearing and measure temporary threshold shift (TTS), or temporary hearing loss, in freshwater turtles. Building from these methods, the team will explore sound exposure levels (SELs) that potentially induce sea turtle TTS onset. If TTS is induced, the team will quantify TTS growth (i.e., rate of increase relative to sound exposure level) and corresponding recovery rates. The work will seek to quantify TTS onset, growth and recovery for initial broadband exposures, followed by more comprehensive broadband exposures and narrow-band sounds.

METHODOLOGY

This project includes three main tasks.

1. Develop a robust, reproducible and safe protocol for testing sea turtle TTS. This includes characterizing potential hearing test environments. The goal



is to determine the enclosures that are best suited for hearing measurements and noise exposures. Methods to manage the turtles and minimize stress during testing (balancing physical stationing and sedation) will be refined.

2. Experimentally examine initial TTS using broadband sound signals in juvenile loggerhead sea turtles (*Caretta caretta*) and green sea turtles (*Chelonia mydas*). Assess and compare initial TTS onset levels, as well as growth and recovery rates for these two species. Empirically determine the apparent range of sound pressure levels (SPL) and durations (i.e., sound exposure levels [SEL]) for effective mapping of sea turtle TTS, to provide the foundation for additional TTS studies. Because green sea turtles have substantially lower hearing thresholds than loggerheads, TTS onset could vary between species. The threshold difference could be as much as 20dB in regions of greatest sensitivity. This could result in varying noise response behaviors between the species.
3. Address and compare, for both species, TTS onset levels, growth rates and recovery rates using 1/6th octave narrowband sound signals. Two fatiguing noise bands of interest will be addressed, as well as at least two hearing test frequencies for each

noise band. Analyses will consider how TTS parameters may differ based on exposure frequency, and how those frequencies relate to the audiogram (i.e., regions of best hearing or more peripheral frequency band).

Results from this set of initial experiments could support later studies to address additional narrow-band, as well as potential additional broadband and intermittent, noise exposures.

SCHEDULE

Started in late 2025, the project is targeted for completion by June 2029. Methods development and data collection for task 2 (TTS using broadband sound signals) will be largely complete at the end of 2027 and efforts for task 3 (comparative TTS assessments), as well as overall study reports, will be completed by June 2029.

NAVY BENEFITS

The TTS data produced by this research will be directly useful for Navy staff and researchers developing the next phase of the Navy Acoustic Effects Criteria, as well as Navy environmental compliance staff conducting analyses of the impacts of Naval sound-producing activities. Currently no TTS data are available for sea turtles and the previously collected TTS data for freshwater turtles are being used for environmental analyses to estimate sea turtle TTS onset.

PRODUCT AND DELIVERABLES

Research results showing TTS onset and growth data for two species of sea turtles will become available through regular reports to the LMR program, presentations at scientific conferences and peer-reviewed publications.

ABOUT THE PRINCIPAL INVESTIGATORS

T. Aran Mooney leads the Sensory Ecology and Bioacoustics Lab within the Biology Department, at the Woods Hole Oceanographic Institution. Dr. Mooney's research focuses on the hearing, bioacoustics and sensory abilities of marine animals. His lab has led the TTS work in freshwater turtles, developing protocols for noise exposure, sedation, calibrations and animal health and safety.



Wendy Piniak is a biologist in the NOAA Fisheries Office of Protected Resources. Dr. Piniak's research focus includes sea turtle acoustic ecology, and she has measured underwater and aerial hearing in diamondback terrapins and five species of sea turtle. She has extensive experience in turtle AEP techniques and examining sea turtle behavioral responses to sound.



Craig Harms is Professor of Aquatic, Wildlife and Zoo Animal Medicine at North Carolina State University and holds a specialty in zoological medicine. Dr. Harms also serves as veterinarian the Karen Beasley Sea Turtle Rescue and Rehabilitation Center and back-up veterinarian for the North Carolina Aquariums. Dr. Harms has pioneered several specialized methods in sea turtle medicine including underwater sea turtle anesthesia, which has been used to collect previous hearing measurements (AEPs) in green sea turtles and diamondback terrapins.

About the LMR Program

The LMR program's fundamental mission is to support the Navy's ability to conduct uninterrupted training and testing, which preserves core Navy readiness capabilities. LMR is an applied research program that funds Navy-driven research needs to support at-sea compliance and permitting. For more information, contact the LMR program manager at exwc_lmr_program@us.navy.mil or visit exwc.navfac.navy.mil/lmr.

