LIVING MARINE RESOURCES PROJECT 45

Frequency-dependent, Underwater Temporary Threshold Shift in California Sea Lions

NEED

California sea lions commonly occur all along the western coast of the continental United States of America, including in Navy training and testing areas. Because there has been limited research on underwater temporary threshold shift (TTS) in California sea lion hearing, the Navy needs additional data to determine appropriate criteria for impact modeling. Data that characterize frequency-dependent underwater TTS across the frequency hearing range of California sea lions are particularly needed.

SOLUTION

This project is testing how sounds of different frequencies may affect the underwater hearing of California sea lions (*Zalophus californianus*).

The goals of the project are:

1. Establish underwater behavioral audiograms for two more California sea lions. Currently behavioral audiograms exist for only four animals.
2. Determine the TTS susceptibility of California sea lions over their entire hearing range.
3. Determine TTS onset sound exposure levels (SEL) and TTS growth after exposure to sounds of various frequencies and SELs.
4. Based on the information derived in items 1–3, construct equal TTS curves (one of which is the TTS onset curve), which can be used to produce an auditory weighting function for California sea lions.
5. Determine which hearing frequency is most affected by each fatiguing sound frequency.
6. Determine the recovery rate of hearing after the fatiguing sounds stop.

The 2-year-old California sea lion, M02, is one of two animals being tested in the temporary hearing threshold shift (TTS) study.
Ron Kastelein

7. Test the equal-energy assumption, which will compare the TTS from two configurations: SEL composed of high sound pressure levels (SPL) for a short duration exposure versus the same SEL composed of a lower SPL for a longer duration exposure.
8. Test the effect of duty cycle (percent of total time sound is being produced).

METHODOLOGY

Two California sea lions, an adult female and a young male, with excellent hearing will be tested within a pool complex designed for acoustic studies. They will be exposed to the fatiguing sounds and their hearing will be tested pre- and post-exposure. The fatiguing sounds will be continuous 1/6th-octave noise bands. Fatiguing sounds with the center frequencies 0.5, 1, 2, 4, 8, 16, 32 and 40 kHz will be tested, with a one-hour exposure duration. This approach is similar to the methods this team used in previous LMR-funded studies of harbor seals (*Phoca vitulina*) and harbor porpoises (*Phocoena phocoena*), so results can be compared directly among the three species.

The equal-energy assumption study will help to address potential effects of naval sonar that often operates at a lower duty cycle and higher sound levels. This study will evaluate two frequencies (4 kHz and 8 kHz) with exposure durations of 10, 20, 40, 64 and 80 minutes. Six duty cycles will be tested: 2.5, 60, 70, 80, 90 and 100 percent. Assessing duty cycle effect for the 4 and 8 kHz exposures will provide data on both the closest frequency to the actual signal of interest (4 kHz) and the scalability of the TTS as a function of duty cycle at 8 kHz.

SCHEDULE

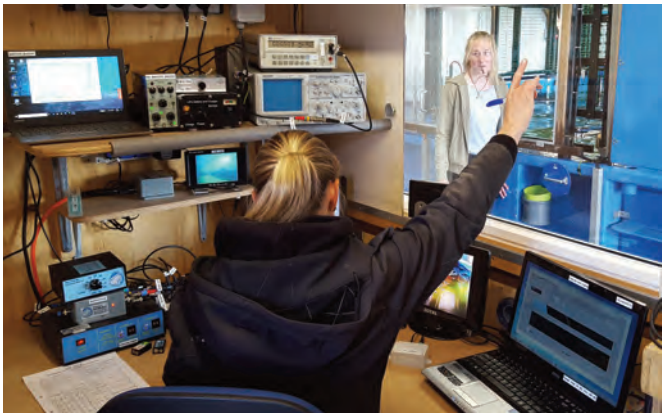
Data collection will be conducted over approximately 40 months, with each fatiguing sound frequency and testing configuration requiring roughly four months. Manuscripts presenting results will be prepared and submitted throughout the project, following sets of testing. The overall project completion is expected during 2023.

NAVY BENEFITS

Navy acoustic impact criteria use auditory weighting functions to predict the onset of TTS and PTS as functions of sound frequency. This project will produce data (a 6dB TTS onset curve) that can be used to improve the weighting function of otariids (eared seals) for environmental impact assessments. The data will be directly applicable to all Navy environmental documents analyzing acoustic effects of tonal sounds (e.g., sonars).

TRANSITION

The primary avenue for distributing project results will be several peer-reviewed journal articles that describe TTS as a function of exposure to sounds of several frequencies. In addition, conference presentations are planned in which preliminary results will be presented. Results will be available to a range of recipients, including 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.



Research assistants and temporary hearing threshold test equipment at SEAMARCO. The equipment operator produces the fatiguing sound and watches for the California sea lion's reaction on a monitor. The trainer waits for a hand signal indicating whether the animal detected the sound and can be rewarded with a fish.

Ron Kastelein

ABOUT THE PRINCIPAL INVESTIGATOR

Since 2002, Ron Kastelein, Ph.D. (University of Wageningen, The Netherlands) has been director and owner of SEAMARCO (Sea Mammal Research Company, Inc.) in The Netherlands. SEAMARCO specializes in applied acoustic research and energetic studies with marine fauna (mammals, fish, turtles and invertebrates).

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.