LIVING MARINE RESOURCES PROJECT 20

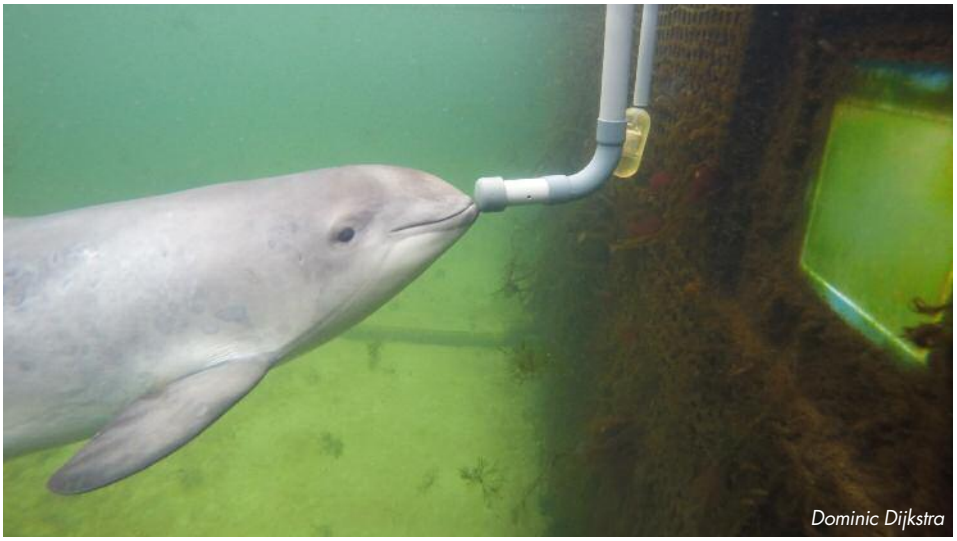
Behavioral Dose-Response Relationship and TTS in Harbor Porpoises

THE NEED

The Navy is responsible for compliance with a suite of Federal environmental laws and regulations that apply to marine mammals and other marine protected species. As part of the compliance process associated with these regulations, the Navy is responsible for implementing a marine species monitoring program to assess potential impacts from Fleet and System Command military readiness activities involving active sonar and underwater detonations. To understand whether these sound sources are affecting hearing and behavior in marine mammals, it is necessary to understand how specific sound pressure levels and sound durations may affect them.

A widely used type of Navy sonar known as 53 Charlie (53C) produces signals in the 3 kiloHertz (kHz) range. These are audible to harbor porpoises (*Phocoena phocoena*), a small odontocete (toothed whale) species that has a wide distribution area, acute hearing, and functional hearing over a very wide frequency range.

It is important to understand the difference between an animal hearing a sound and that sound causing an effect—either a behavioral effect or a physiological effect on hearing known as a temporary threshold shift (TTS). Based on the presently available information, neither TTS nor behavioral responses can be predicted for harbor porpoises due to exposure to 3 kHz sonar signals.



A harbor porpoise at a listening station during hearing threshold assessment at SEAMARCO.

THE SOLUTION

This project team, led by Ron Kastelein, is working to determine which hearing frequency of harbor porpoises is most affected by 3 kHz signals. TTS growth curves due to sound pressure level, sound exposure duration, and duty cycle will also be established. From these curves, the TTS onset cumulative Sound Exposure Level (SEL) can be derived. (TTS is caused by a combination of sound pressure level and exposure duration, which are both combined in SEL.) The duty cycle plays an important role because it determines the sound energy per time unit that reaches the ears, and also because hearing may also (partly) recover in the pauses between signals.

THE METHODOLOGY

This project is split into two main phases: the behavioral dose-response phase and the TTS phase. Both studies will take place at SEAMARCO Research Insti-

tute in the Netherlands. For the behavioral dose-response phase, porpoises will be exposed to 3 kHz sounds at five levels, both with and without additional background noise. Porpoises will be filmed during sessions composed of 30 minute baseline periods and 30 minute exposures. Parameters that will be analyzed are respiration rate, distance to the sound source, and swimming speed.

In the TTS phase of the project, trained porpoises will wait at a listening station, at a specific distance from the underwater loudspeaker. When they hear a sound they will leave the station and swim towards the trainer for a reward. Each session will include a pre-exposure hearing test, exposure to the signal, and several post-exposure hearing threshold measurements to determine the rate of recovery of hearing.

First it will be determined which hearing frequency(ies) are most affected by the 3 kHz sonar signals. Secondly, TTS growth curves will be established due to sound pressure level, exposure duration, and duty cycle. From these curves, TTS onset cumulative SEL can be derived, and permanent threshold shift onset cumulative SEL can be estimated.

THE SCHEDULE

During the first behavioral response study, planned to start mid-2016, one behavioral response session will be conducted daily. This test period will last 2.5 months. Then, the experiment will be conducted in five background noise levels, resembling sea states 0, 2, 4, 6 and 8. This phase will also take 2.5 months. The TTS phase will begin in fiscal year (FY) 2017. The entire TTS study is expected to be complete by mid FY18.

NAVY BENEFITS

At present, accurate data to assess the impact of the widely used 53C sonar on harbor porpoise hearing and behavior is not available. This project will determine a behavioral response threshold level under quiet conditions, and under various ambient noise levels. These findings will enable the calculation of realistic impact zones for this sonar system, which ultimately should contribute to making the number of harbor porpoise "takes" more realistic. The TTS growth curves can be used by regulators to set realistic safe underwater sound criteria to prevent hearing injury in harbor porpoises.

TRANSITION

The U.S. Navy and governments can use the information collected over the course of this project to set more realistic underwater sound safety criteria. The final report will be in the form of a manuscript which will be submitted to the Journal of the Acoustic Society of America for publication.

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 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.lmr.navy.mil.