LIVING MARINE RESOURCES PROJECT 69

Effect of Signal Duration on Perceived Loudness in Bottlenose Dolphins and California Sea Lions

NEED

To understand the potential effects of sounds created by Navy training activities on marine mammals, the Navy needs information not only on physiological effects (i.e., temporary threshold shift, permanent threshold shift), but also how sounds can influence marine mammals' behavioral response. Both context and perceived components of the sound, rather than the physical characteristics alone, may contribute to response. One perceptual component of sound is perceived loudness and one factor that may lower perceived loudness, and therefore reduce the potential for a behavioral response, is the duration of the sound or signal.

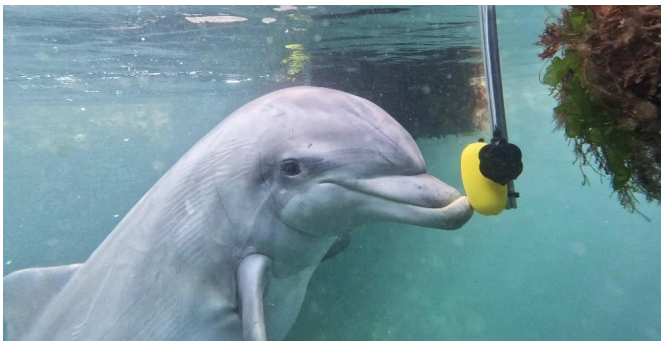
SOLUTION

This project will evaluate perceived loudness of acoustic sources, which is likely a better predictor of animal behavioral responses than received level. The duration of each individual sound likely influences how marine mammals perceive how loud the sound is and how they will respond. While other studies have provided information on the basic properties of temporal summation (how an animal integrates sound over time) at the detection threshold in marine mammals, they are not fully applicable to estimating effects for sound pressure levels (SPL) above the detection threshold.

Measurements above the hearing threshold are of greater relevance to Navy analyses and signal duration will have an important effect on loudness perception.

METHODOLOGY

The project team will test both the relationship of hearing sensitivity to sound duration for a wide range of frequencies, and the relationship between perceived loudness and sound duration. The team's first two tasks will work with bottlenose dolphins. A possible third task would test California sea lions.



A dolphin touches the response paddle with her rostrum. The black sound transducer used for training is attached to the paddle.

Jim Finneran

Task 1: Threshold of signal duration audibility across the hearing range in dolphins

This task will use behavioral methods to test two trained bottlenose dolphins (*Tursiops truncatus*). The team will measure the threshold at which signals are audible for frequency-specific stimuli with durations between 25 and 1000 milliseconds (ms). The frequencies used will reflect a sample across the hearing range of dolphins (5, 10, 20, 40 and 80 kHz). Background masking noise will be played during testing to exceed the ambient sound in the testing location, which will elevate hearing thresholds to levels near those of Navy sources (>100 dB). Thresholds will be determined for each combination of frequency and duration for each masking condition.

Task 2: Perceived loudness as a function of signal duration in dolphins

This task also will use behavioral methods to test two trained bottlenose dolphins (*Tursiops truncatus*). Perceived loudness will be measured using a loudness comparison test, in which the dolphin indicates

which of two sequential tones is louder. The dolphin will indicate which sound (the first or the second) is louder by pressing the corresponding response paddle (i.e., a two-alternative choice task). A reference sound is played at a consistent SPL, frequency and duration across all trials, and the comparison sound is varied in SPL and duration from trial to trial. Whether the reference sound or comparison sound is played first will be randomized. Responses from multiple trials will be used to describe the relationship between duration and loudness.

Results from the respective tasks will be used to assess how faithfully the patterns observed in the Task 1 detection threshold data represent actual loudness perception. The project also will provide equal-loudness contours that represent the SPL/duration combinations that create a sensation of equal-loudness magnitude for each test frequency.

Task 3 (optional): Threshold of signal duration audibility across the hearing range of sea lions

An optional task would collect behavioral detection thresholds from two trained California sea lions *(Zalophus californianus)*. Test frequencies will be 1, 2, 4, 8 and 16 kHz, and all other study details will be the same as for dolphins in Task 1.

SCHEDULE

Tasks 1 and 2 will be conducted during 2024 and 2025. If task 3 is undertaken, it will be performed during 2026.

NAVY BENEFITS

The results of this project will support Navy environmental compliance. Navy behavioral response functions are important to evaluating the Navy's environmental impact on marine mammals. The equal-loudness contours could be used to weight these response functions to reflect how perceived loudness changes with source duration.

Two-alternative forced-choice task training. A dolphin responds to sound originating from a response paddle by touching it. The trial began with the center trainer sending the dolphin to the blue bite plate. The response paddles were gradually moved to be equidistant.

Jim Finneran

TRANSITION

In addition to providing data to the Navy's environmental compliance personnel, results will be submitted for peer-reviewed publication and presentation at relevant professional conferences.

ABOUT THE PRINCIPAL INVESTIGATOR

Alyssa Accomando is a neuroscientist with over seven years of experience conducting research at NIWC Pacific, specializing in animal bioacoustics with environmental and technological applications. Her research includes auditory processing and perception in echolocating animals. Dr. Accomando earned her Ph.D. in neuroscience at Brown 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@us.navy.mil or visit exwc.navfac.navy.mil/lmr.