Behavioral Audiometry in Multiple Killer Whales

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, including the Endangered Species Act and the Marine Mammal Protection Act. As part of the regulatory compliance process associated with these Acts, 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 from explosives and explosive munitions. To understand whether these sound sources are impacting hearing in marine mammals, it is necessary to understand the natural or baseline hearing in these mammals.

and require replication and validation. Furthermore, the limited data fails to provide any insight into individual differences or demographic variability (e.g., age) in hearing capabilities that have been demonstrated in other odontocete species, such as the bottlenose dolphin. The primary reason for such sparse data is limited access to trained killer whales for behavioral audiograms and the difficulty in measuring AEP thresholds with large animals.

A killer whale positioned on a stationing device while participating in a psychophysical hearing test.

Killer whales (*Orcinus orca*) are the most widely distributed marine mammal species and have recently been suggested as being an extremely sensitive species to acoustic disturbance. Although auditory evoked potential (AEP) hearing tests have certain advantages with respect to ease of data collection, the "gold standard" in audiometric testing and accuracy remains the behavioral audiogram. To date, only two complete behavioral audiograms from two adult female killer whales exist. These audiograms, compiled in 1999, returned questionably low threshold levels (lower than any odontocete tested)

THE SOLUTION

In early 2014, the National Marine Mammal Foundation (NMMF), SeaWorld San Diego, and SeaWorld San Antonio participated in a cooperative effort to obtain behavioral audiometry from SeaWorld's killer whale collection. This effort, which directly supports Navy environmental compliance, was partially funded by U.S. Fleet Forces Command. It is the goal of this new project, headed by Principal Investigator Brian Branstetter of NMMF, to complete the audiograms of the whales at SeaWorld San Diego, potentially add

extra subjects from that facility, and add additional subjects from SeaWorld San Antonio.

THE METHODOLOGY

The study will provide the first demographic hearing data from killer whales by measuring behavioral audiograms from five to eight participants that vary in age (12 to 49 years) and gender. Additional subjects may become available during the course of the study. Audiograms will be measured using well-established psychoacoustic methods that are regularly employed by the NMMF for the testing of hearing in dolphins. Psychophysical hearing tests are the "gold standard" of hearing tests, leading to the most accurate audiometric measurements. The whales are housed at SeaWorld San Diego and SeaWorld San Antonio, where the experiments are in progress. A collaborative arrangement exists between SeaWorld and the NMMF for SeaWorld killer whales to participate in audiometric studies.

THE SCHEDULE

The success of this effort relies on the ability to train multiple killer whales to perform a psychophysical hearing test. Sea World San Diego has allocated three trainers (one of which is a senior trainer/manager) for this task. Sea World San Antonio has assigned one of their senior trainers to head data collection in San Antonio. Personnel in both locations have undergone training in San Diego to use the software and hardware for the hearing tests. Additional training will take place on-site in each location. In addition, Principal Investigator Branstetter has 21 years of experience in psychoacoustics and 18 years of marine mammal research training experience and is overseeing all aspects of animal training for this effort.

NAVY BENEFITS

Lack of knowledge of hearing capabilities and the effects of sound on marine mammals continues to challenge Navy environmental compliance efforts. Data from this study will more than double the number of individual killer whales that have been tested, as well as provide hearing data over a large age range of 12 to 49 years. This will help to determine accurate mid-frequency cetacean composite audiograms and weighting functions for Navy at-sea environmental compliance.

TRANSITION

The results from the study will be published in a peer-reviewed acoustical journal and presented at professional conferences. The data can be used in Navy compliance documents as well as computer models that address the effects of auditory masking on marine mammals.

ABOUT THE PRINCIPAL INVESTIGATOR

Brian Branstetter is a research scientist at the National Marine Mammal Foundation. His research interests are conservation-based and focus on marine mammal psychoacoustics and cognition, echolocation, auditory masking, whistle production and perception, and vigilance in dolphins. He received his Ph.D. from the University of Hawaii, Manoa.