Developing Tools for Acoustic-only Behavioral Response Studies at Navy Instrumented Ranges

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 (ESA) and the Marine Mammal Protection Act (MMPA). 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 Systems Command (SYSCOM) military readiness activities involving active sonar and the use of explosives/explosive munitions.

To meet regulatory requirements, the Navy needs information about how protected marine species respond to sound exposures. Ongoing behavioral responses studies entail at-sea, boat-based visual detection, tagging, and tracking of animals in coordination with simulated sound sources and Navy ships. An alternative, and complementary, method to this logistically difficult approach could expand the Navy's knowledge of how marine mammals respond to sound.

THE SOLUTION

The Space and Warfare Systems Center Pacific (SSCPAC) has been collecting data from hydrophone arrays on the U.S. Navy's Pacific Missile Range Facility (PMRF) to acoustically monitor marine mammal activity since 2003. Such long-term monitoring has created robust acoustic data sets, both in types and quantity of data. In addition, relatively recent advances in localization software development have allowed SSCPAC to acoustically detect, localize, and track several species of whales including beaked, humpback, minke, Bryde's, fin, sei, and sperm whales.

With appropriate new tools, this combination of data and software advancements could offer an opportunity to conduct acoustic behavioral response studies on Navy ranges. Such methods could support more efficient studies of marine mammal response to sound on Navy at-sea ranges.
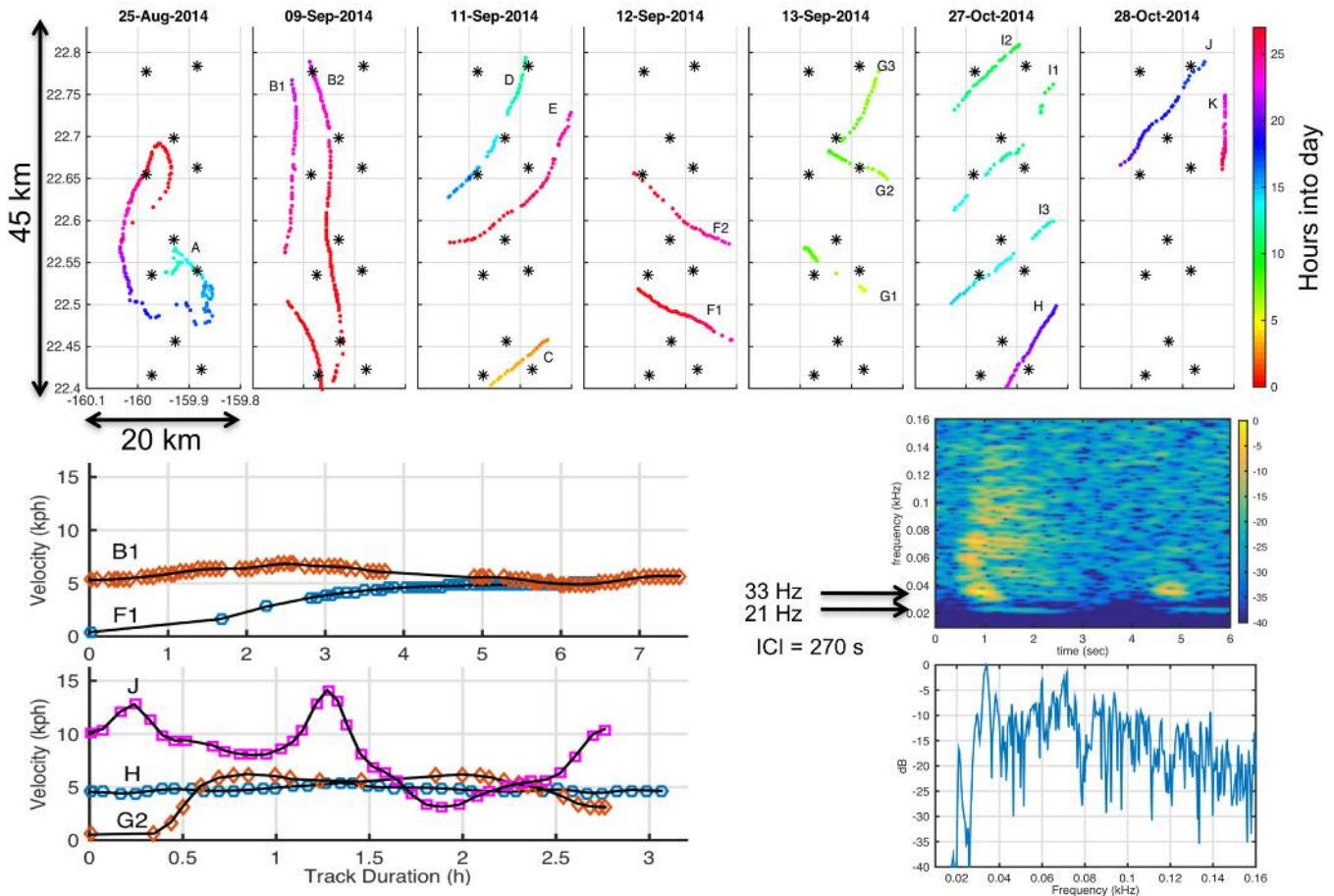

CETOS Research Organization, permit 1039–1699

Bryde's whale.

THE METHODOLOGY

This partnership effort will provide support for developing the tools needed to efficiently conduct basic behavioral response assessments. The tools will be used to support both the Office of Naval Research (ONR) effort, titled "Behavioral Response Evaluations Employing robust baselines and actual Navy training (BREVE)," and ongoing reporting required by Commander, U.S. Pacific Fleet (PACFLEET).

The primary goal of ONR's BREVE project is to develop and apply methods to determine baleen whale species' behavioral responses to actual Navy training using passive acoustic monitoring (PAM) data from dense hydrophone arrays. The BREVE portion of the work will establish metrics and statistical methods for quantifying behavioral responses to training.

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Bryde's whale track kinematics and signal characteristics

Within the LMR portion of this effort, the project team will develop three software tools to help analyze metrics needed for the ONR BREVE effort and PACFLEET monitoring efforts:

1. An interface for acoustic modeling software to automatically estimate sonar sound pressure levels (SPL) and sound exposure levels (SEL) to tracked animals. The interface will be designed for available Navy standard models in order to automate the SPL/SEL estimation process. The team will also use "Peregrine," a C-code version of the Range Dependent Acoustic Model (RAM) developed by OASIS.

2. Automated track kinematics software to group whale localizations into tracks and to automatically extract relevant swim kinematics (e.g., animal's speed, direction, depth, etc.). The methods developed within this tool will allow for automatic implementation of metrics developed under the BREVE project. This will allow for bulk processing of tracks to reduce the need for human operator involvement.

3. Automated classifier for track information to process the thousands of tracks contained in archived datasets, in addition to new data. This will integrate available classifiers, with modifications as needed to work on the PMRF and the Southern California Offshore ranges.

These three tools will support efficient marine mammal reporting on Navy instrumented ranges, particularly if information beyond species-specific presence/absence is to be reported. Even in the limited case of species-specific presence/absence,

considerable operator time is currently needed to classify calls. The amount of time and effort spent on manually identifying species, assigning tracks and estimating exposure levels for just a few select cases is considerable. These automated tools ultimately will facilitate work for PACFLEET monitoring.

THE SCHEDULE

During year one the team will analyze and modify both the Navy standard models and Peregrine to handle SPL/SEL batch processing, as well as estimate and validate automated sound level (SL) outputs against manual results. During year two, the team will develop, tune and validate the automated track kinematic software using BREVE metrics, as well as start the platform for automated species classification, using detection, kinematics and SL software. In the final year, the team will develop and test species-specific classifiers for each species and validate against human results and provide batch results for relevant species to BREVE/PACFLEET.

NAVY BENEFITS

These tools will help the Navy to quantify behavioral responses of marine mammals to Navy sonar in an impartial and methodological manner that can be replicated at other Navy ranges and extrapolated to additional vocally-active marine mammal species. The tools also will allow researchers to better understand the relationship between behavioral responses and contextual factors, including distance to the sound source, behavioral state of the animal and impacts of repeated exposures. Automating labor-intensive tasks will ultimately save money and allow for more datasets to be analyzed. In addition, the tools will provide an efficient means for studying non-BRS related marine mammal ecology.

TRANSITION

The three tools will be utilized by end users directly involved in Navy marine species monitoring efforts on Navy ranges. The tools will also be made available to other collaborators working on Navy ranges. With minor modifications, the software could be used on non-navy ranges for use in other deployments that include coverage with multiple overlapping hydrophones. Tool descriptions and resulting behavioral analyses will be published in Navy reports, peer-reviewed journal publications, and will be presented at scientific conferences.

ABOUT THE PRINCIPAL INVESTIGATORS

Since 2004, Tyler Helble has been an engineer at Space and Naval Warfare Systems Center in San Diego working on Autonomous Underwater Vehicle (AUV) systems, passive acoustic monitoring, signal processing, and whale acoustics. He holds a Ph.D. in Oceanography from the University of California, San Diego.

Elizabeth Henderson, a bioacoustic scientist, joined the Navy Marine Mammal program at the Space and Naval Warfare Systems Center in 2014. She focuses on bioacoustic and noise impact analyses for environmental compliance. She holds a Ph.D. Marine Biology and Biological Oceanography from the University of California, San Diego.