



## LIVING MARINE RESOURCES PROJECT 5

# Developing Automated Whistle and Click Detectors and Classifiers for Odontocete Species

### 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 regulatory compliance process, the Navy has developed 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. Passive acoustic monitoring (PAM) methods have been adopted as a cost-effective approach for collecting data about and monitoring the occurrence and distribution of marine mammals. While effective, PAM generates huge volumes (many terabytes/year) of data. In order for this technology to be efficiently utilized and the data generated to be interpreted effectively, reliable, automated acoustic analysis software programs are needed.

The variability inherent in many sounds produced by odontocetes (toothed whales such as dolphins) makes it difficult to automatically detect and classify them to species. Sounds produced by odontocetes—particularly dolphin species—can be grouped into one of two broad categories: whistles and pulsed sounds (e.g. clicks). Previously, separate whistle and click classifiers have been developed for specific dolphin species. However, not all species produce whistles, or they may only produce whistles or clicks in specific behavioral contexts. As such, combining information from different types of sounds may provide more power for identifying species than classification based on only one sound type at a time. Therefore, an automated classifier that includes information from both whistles and clicks as well as other contextual information (e.g. location, number of whistles, number of clicks, overlap among sounds, etc.) would advance the science of automated classification.

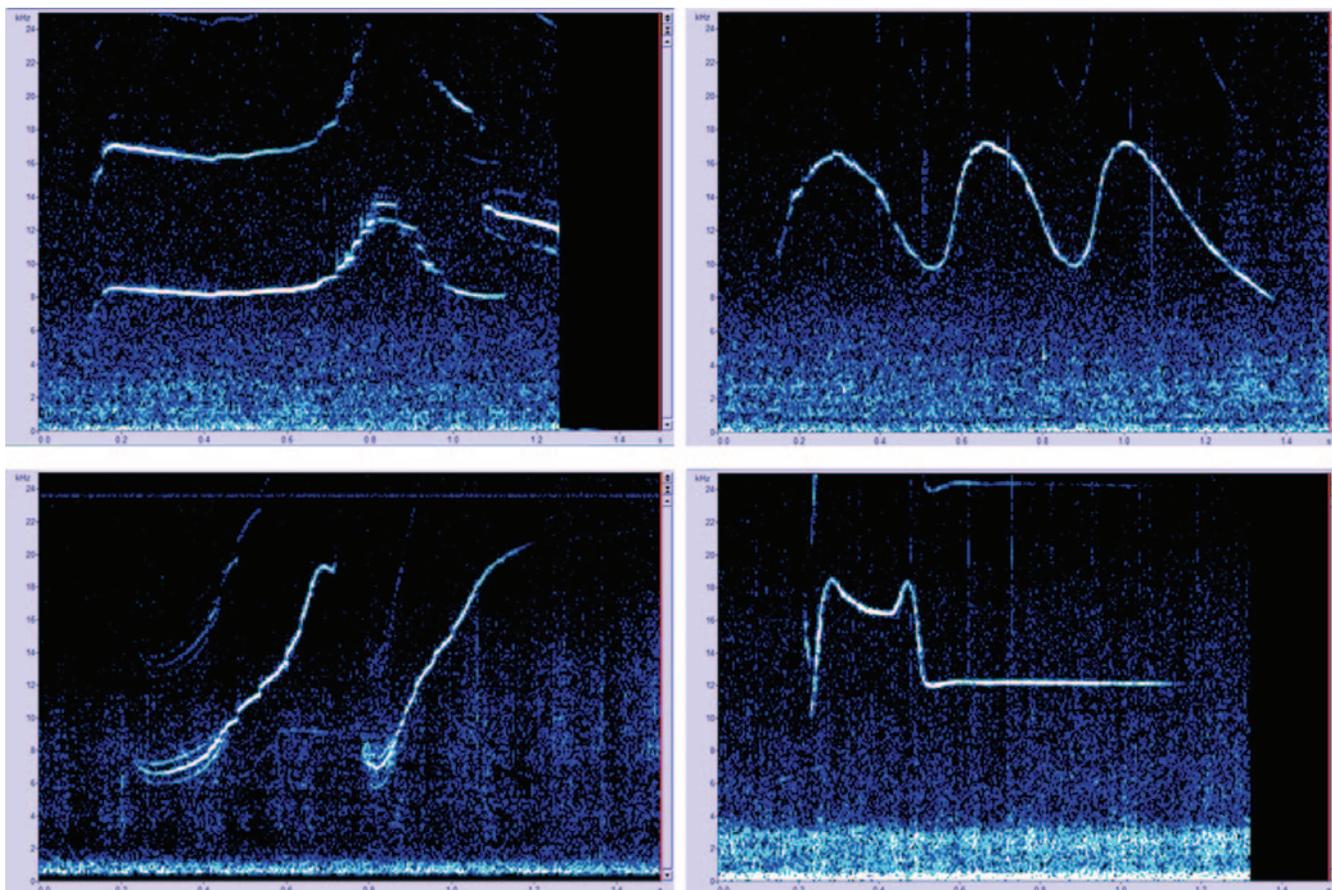
### THE SOLUTION

This project involves the development of classifiers that use information from whistles and clicks as well as variables related to location and acoustic behavior to classify sounds produced by odontocete species on naval ranges. Three geographic classifiers will be available at the end of the project: one for odontocete species in the waters surrounding the Hawaiian Islands, one for species in the temperate Pacific Ocean and one for species in the northwestern Atlantic Ocean. Some stages of the project are being funded by the LMR program while others are being funded by the Office of Naval Research (ONR).

### THE METHODOLOGY

The project team is using existing acoustic data to create fully automated whistle and click classifiers for odontocete species in three locations. Additionally, contextual information such as vocalization rates (number of whistles and/or clicks per second), relative abundance of whistles and clicks, and latitude of acoustic detections will be included in a 'context' feature vector. Combining whistle, click, and context feature vectors to produce a final classification will provide a tool for efficiently and automatically processing the large datasets generated during PAM projects.

Classifiers developed during the course of the project will be incorporated into existing whistle classifier software called the Real-time Odontocete Call Classification Algorithm (ROCCA). ROCCA currently is available as a module in the marine mammal passive acoustic data processing software program, PAMGuard. The updated classifiers will be made available for use in PAMGuard as well as in another widely used software package, Ishmael.



Whistles produced by striped dolphins. These whistles illustrate the high within-species variability in whistle structure that exists in most delphinids.

## THE SCHEDULE

The team has detected and extracted whistles from acoustic recordings of bottlenose dolphins, short-beaked common dolphins and melon-headed whales using three different automated tonal detectors (PAMGuard's whistle and moan detector, Ishmael's tonal detector and *Silbido* software). The output of these automated detectors were compared using a variety of metrics. All three performed well, each having precision scores greater than 75 percent for all species combined. Based on the strengths and weaknesses of each detector, the team decided to integrate PAMGuard's whistle and moan detector with ROCCA. Using this tonal detector/ROCCA combination, whistles have been detected, extracted and measured from acoustic recordings made in the northwest Atlantic, Hawaii and the temperate Pacific. Clicks have also

been detected and measured from these data using PAMGuard's automated click detector and new click measurement functionality which has been added to send measurements to ROCCA. Preliminary results from a comparison of clicks produced by species recorded in the northwest Atlantic suggest that significant differences exist in multiple click parameters and that the addition of clicks to classifiers will increase classification success.

In an ONR-funded effort, capabilities to measure context variables have been developed within PAMGuard. These capabilities will be used to measure context variables from recordings made in the three locations. Classifiers will then be developed that identify encounters to species based on all of the available feature vectors. Methods will be developed and tested during the ONR portion of this project using data from

the northwest Atlantic and Hawaii. The classification approach developed in the ONR portion of the project will then be used to create classifiers for species in the temperate Pacific Ocean. At the end of the project, all new classifiers will be integrated into PAMGuard and Ishmael software packages. This portion of the project will be funded by LMR.

## NAVY BENEFITS

The fully automated methods developed under this project will significantly reduce the time and cost required for the processing of PAM data. In addition, adding feature vectors for clicks and context data is expected to provide better classification results and therefore a more accurate representation of species distribution on and around Navy training ranges.

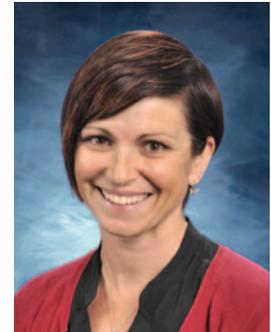
## TRANSITION

Current users of PAMGuard and Ishmael software will be able to download the updated versions as soon as they are available. Announcements will be posted on the Marine Mammals Research and Conservation Discussion and Bio-Acoustics-L list-serves. In addition, the team will inform all Navy marine species monitoring program participants of the new classifiers, and will host a teleconference/demonstration for all interested parties.

*For more information about this project, visit [www.bio-waves.net](http://www.bio-waves.net).*

## ABOUT THE PRINCIPAL INVESTIGATORS

**Principal Investigator:** Julie Oswald is Vice President and Senior Scientist at Bio-Waves, Inc. She participates in analyzing bio-acoustic data, developing tools for passive acoustic monitoring, and providing assessments of the effects of noise on the marine environment. Dr. Oswald has a Ph.D. in Oceanography from Scripps Institution of Oceanography.



**Co-Principal Investigator:** Tina Yack is Managing Director and Senior Marine Ecologist at Bio-Waves, Inc. She works in development and testing of towed hydrophone array hardware and passive acoustic monitoring and analysis software. She has expertise with Generalized Additive Modeling techniques to model cetacean distribution and habitat preferences using passive acoustic data, as well as distance sampling methods for estimating acoustic based density estimation of deep diving odontocetes. She received her Ph.D. from the University of California—Davis/San Diego State University Joint Doctoral Ecology program in 2013.



## 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](mailto:exwc_lmr_program@navy.mil) or visit [www.lmr.navy.mil](http://www.lmr.navy.mil).

