



## LIVING MARINE RESOURCES PROJECT 1

# Marine Mammal Monitoring on 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 direct, empirical information about protected marine species on Navy training ranges. This includes knowledge about marine mammal presence, distribution, movement, abundance and behavior using an ensemble of passive acoustic monitoring, visual observation, biological sampling, and satellite tagging methods.

### THE SOLUTION

Navy at-sea training ranges are equipped with sea-bottom hydrophones (underwater microphones) to track sounds across the range. Marine mammal sounds can also be detected by the hydrophones. As years of marine mammal research have revealed, different species vocalize at different frequencies and have distinguishing types of sounds (clicks, series of clicks, whistles, moans, hums, etc.), of which some allow us to identify species from sounds alone. These sounds are detected on individual hydrophones as an animal, or group of animals, vocalizes within the range. The Marine Mammal Monitoring on Ranges (M3R) was initiated to determine how equipment on Navy ranges might be used to monitor for marine mammals.

The goals of the M3R program are to:

1. Develop automated passive acoustic marine mammal detection, localization, classification and display tools using existing Navy undersea hydrophone arrays and integrate visual and satellite monitoring methods to leverage the combination of the methods to study marine mammals on Navy ranges.
2. Study and measure animal responses to Navy activities, including mid-frequency active sonar (MFAS), with a focus on beaked whales.
3. Provide scientifically defensible behavioral response metrics for sensitive species like beaked whales, which can be used to inform regulatory risk criteria and provide insight into the cumulative effect of repeated sonar exposure.
4. Provide baseline population density, abundance, and habitat usage data for Navy risk analyses and permit applications covering training and testing activities on the ranges.

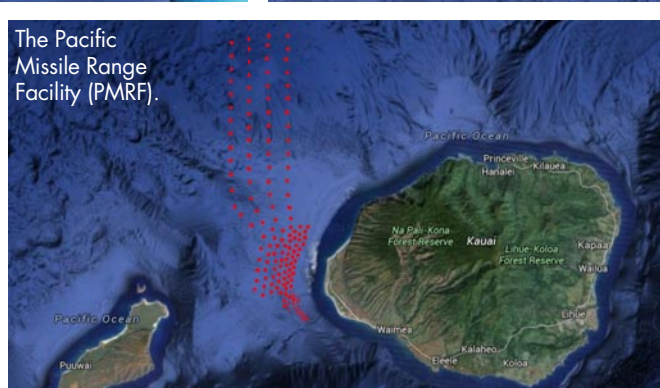
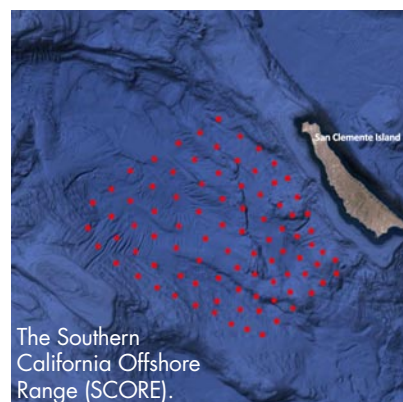
Ultimately, to significantly improve Navy monitoring capabilities, the Navy will need approaches to passive acoustic monitoring that do not require marine mammal experts to collect the data. One focus of moving to transition M3R capabilities was to develop a system that could be run by existing Navy range personnel to collect data prior to, during, and after training and testing exercises. Implementing these tools on existing fields of hydrophones on Navy ranges allows us to leverage and enhance existing methods available to the Navy.

### THE METHODOLOGY

The M3R program is currently being developed and integrated at three Navy undersea ranges equipped

with arrays of broadly-spaced (1-4 miles), bottom-mounted hydrophones:

1. The Atlantic Undersea Test and Evaluation Center (AUTEC) in The Bahamas
2. The Southern California Offshore Range (SCORE) at San Clemente Island, California
3. The Pacific Missile Range Facility (PMRF) in Barking Sands, Hawaii.



The red dots show the hydrophones in the arrays.

Initial monitoring algorithms were developed and implemented on the Versa Module Europa (VME)-based range DSP. A stand-alone Linux cluster-base architecture was designed and implemented. M3R inspired the range operational community to adopt the architecture for use on the major Navy ranges as the main range tracking signal processor for training and testing.

The M3R program also has developed a digital signal processor (DSP) architecture that incorporates hardware and software to capture and process marine mammal sounds, classify some species of marine mammals by their vocalizations, estimate locations, and display the results in both time and frequency. Real-time detection reports are archived and available for post-analysis.

To verify the passive acoustics data, on-water sighting data are being collected to provide a direct observation of species identification, physical behavior, group size, and population demographics along with biopsy sampling and prey mapping. These data provide insight into population dynamics and prey utilization on the ranges. Biopsy samples are used for an Office of Naval Research (ONR) funded project studying hormone analysis as possible stress indicators and fatty acid analysis to gain insight into prey utilization. During focused field efforts during the year, satellite tags are also being attached to selected animals to measure both their dive behavior and their movement over the span of months both on and off the range. When possible

these data are evaluated along with precise ship tracks and sonar received level measurements, to investigate the effects of repeated sonar exposure on cetaceans. The focus of this study is on deep diving Blainville's (*Mesoplodon densirostris*) and Cuvier's (*Ziphius cavirostris*) beaked whales, which have been the predominant species present in stranding incidents related to sonar. The real-time passive acoustic monitoring capability of M3R has proved to be a significant aid to the tagging field team to find these cryptic species.

## THE SCHEDULE

M3R was initiated in 2000 by ONR to investigate the possibility of leveraging existing Navy range hydrophones to monitor cetaceans. The program documented the presence of Blainville's beaked whales on a Navy range where MFAS was routinely used. In 2009, the core M3R program development was transitioned from ONR to LMR and prototype technologies were extended and used to study animals on the

ranges. M3R is transitioning its monitoring and analysis tools so that they might be run and maintained by Navy range personnel.

During FY15 the project completed significant system updates at all three ranges (AUTECH, SCORE, PMRF), improved system stability and upgraded hardware, installed packet recorders to archive raw acoustic data and completed the user manual.

## NAVY BENEFITS

Because the M3R system and range tracking systems employ identical system architectures, the project's transition will contribute to maintaining an overall integrated system software repository. It will help to ensure that the M3R algorithms are maintained under the structured source code control implemented for range signal processing systems, thus helping the Navy to protect its long-term investment and reduce the maintenance costs for both systems. It also will ensure that the system remains active and meets the current Department of Defense requirements for Information Assurance. M3R will be available for further expansion and development by Navy and through collaboration with the PI, can be further developed by outside scientists.

## TRANSITION

Currently, the core capability and operation of M3R is being transitioned to the Navy Marine Species Monitoring program. This will allow for continuous monitoring of animals on the ranges and will provide ongoing data to evaluate changes in beaked whale abundance, density and distribution on the ranges based on acoustic detections.

In addition, M3R data collected under the LMR program are being used to develop improved

behavioral risk criteria, the results of which will be applied to the Navy's acoustic impact analysis for Phase III environmental compliance. ONR investments play a vital role in analyzing M3R observations as integrated models of animal response to sound and further studying the possible biological significance of those responses.

As the core function of the M3R technology is transitioned, the breadth of data available on marine mammals will substantially increase. This will assist in providing insight on understanding baseline cetacean behavior and the potential effects from training and testing. This will provide real-time marine mammal monitoring capabilities in support of range operations.

## ABOUT THE PRINCIPAL INVESTIGATOR

David Moretti has over 30 years' experience in acoustic signal processing working as an engineer and scientist at the Naval Undersea Warfare Center (NUWC). He developed the NUWC Ranges' Department Digital Signal Processing (DSP) Team and has also led the Tracking and Environmental Modeling Team. He currently leads the Marine Mammal Monitoring on Navy Ranges (M3R) program and for the last 20 years has focused his research on the development and application of marine mammal passive acoustic algorithms and systems for the in-situ study of cetaceans, with a focus on beaked whales. He holds a Master's degree in electrical engineering from Marquette University and Bachelor's degrees in genetics and resource management from the University of Wisconsin.



## 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).

