Latest Behavioral Response Study Builds Upon Years of Marine Mammal Research

Mediterranean Whale Behavior Studies Provide Foundation for Today's Efforts

IN 1996, A mass stranding of Cuvier's beaked whales in Greece occurred in close proximity to a North Atlantic Treaty Organization (NATO)-sponsored research cruise using low- and mid-frequency active sonar. A subsequent investigation into the incident concluded that "an acoustic link can neither be clearly established nor eliminated as a direct or indirect cause for the May 1996 strandings." (For more information, see D'Amico, A., & Verboom, W. C.: Summary Record and Report, SACLANTCEN Bioacoustics Panel, La Spezia, Italy, 15-17 June 1998 and Summary Record, Marine Mammal Environmental Policy and Mitigation Procedures Panel; La Spezia, Italy 17-19 June 1998.) The investigative panel recommended that additional research was needed to determine the effect of active sonar on marine mammals.

Based on this recommendation, the NATO Undersea Research Centre (NURC) created one of the first research programs in the world to address this topic—the Sound Ocean Living Marine Resources program, now known as the Marine Mammal Risk Mitigation (MMRM) program.

The program is a multinational, multidisciplinary research project with the objective of learning more about whale behavior, and developing tools and technology with which an experimenter can determine the presence of marine mammals using both visual and passive acoustic methods.

To help determine the location and density of whales in the Mediterranean Sea, and to evaluate the effectiveness of different passive acoustic monitoring methods, a series of sea trials was instituted. These trials, collectively known as "Sirena," were conducted between 1999 and 2010 in the Mediterranean Sea. The early trials were conducted in the Ligurian Sea, a deep basin in the northwest Mediterranean. Scientists were able to survey locations of various cetaceans during these trials, and behavioral data collected during the trials advanced knowledge of normal beaked whale behavior in the Ligurian Sea so that behavioral responses to human activities could be better understood. The Sirena 08 trial was conducted in the Alboran Sea. The identification of high-density beaked whale regions within the Alboran Sea enabled researchers to return to a known beaked whale habitat during the trials held in the Mediterranean Sea in 2009, commonly referred to as "MED 09."

> We are pushing the boundaries of what is possible in studying some of the most reclusive animals on earth.
>
> *—Brandon Southall*

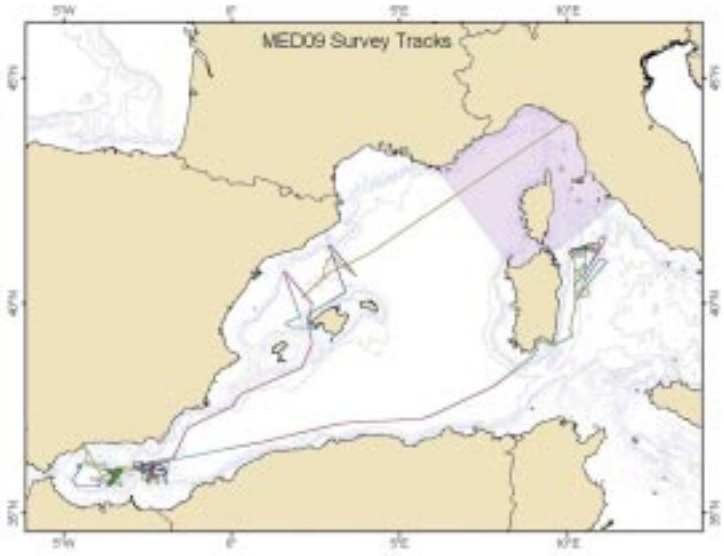
The Sirena trials provided researchers and military commanders with aids to assess the potential for a given area of the sea to contain whales and other marine mammals that may be impacted by the use of active sonar. The trials also assisted in the development of mitigation protocols for use during training exercises, and other

educational tools. These included passive acoustic monitoring, predictive habitat and sound propagation models, a web site and a guiding policy. Since the initial policy was developed in 1999, no known marine mammal strandings have occurred in spatial or temporal proximity to NURC experiments.

The approach adopted by NURC includes engaging academia, government, private sector scientists, and environmental organizations into its MMRM program. Over 20 participants from nine countries have contributed resources including software, technologies, data, and personnel to the planning, execution, and analyses of sea trials. In 2005, 2007 and 2009, NURC organized three intergovernmental conferences entitled "The Effects of Sound in the Ocean on Marine Mammals." Over 175 individuals from 11 countries participated in these events, which provided a forum for military personnel and government-funded scientists to discuss the status of current research regarding the potential impacts of sonar on marine mammals. In addition, current mitigation methods employed by national navies were shared. These conferences provided opportunities for discussion of coordinated efforts and future collaborations to make the most of limited research funding and to eliminate duplicative efforts.

Marine Mammal Research & the Navy

In the U.S., the Navy is a participant in multiple research efforts regarding whale behavior and active sonar use. In 2007 and 2008, Behavioral Response Studies were conducted at the Atlantic Undersea Test and Evaluation Center (AUTEC) in the Bahamas. In these studies, whale movement and behavior was studied with and without the presence of active sonar signals similar to those used in operational training exercises, as well as other sounds.



The route of the MED 09 study.

The Alliance was the research vessel used for MED 09.

Large groups of pilot whales were encountered during MED 09.
Hundreds of high quality identification photographs were made on multiple days at close range.
U.S. National Marine Fisheries Service permit number 14241 issued to Peter Tyack

(To read more about these projects, see our stories entitled "Navy Leads the Way in Marine Mammal Science" in the winter 2009 issue of *Currents*, and "Spotlight on Dave Moretti, Principal Investigator for the Navy's Marine Mammal Monitoring Program Outlines Priorities and Projects" in our winter 2010 issue. Both are available for viewing and downloading online at www.enviro-navair.navy.mil/currents.)

The 2009 Mediterranean Trials

The summer of 2009 saw new accomplishments in the study of marine mammal behavioral patterns and habitats. The multinational MED 09 study was conducted in the Mediterranean Sea between late July and early September 2009. Despite its cultural and historical significance, the deep water, off shore regions of this area have remained relatively uncharted by the world's marine mammal researchers. "Many of the areas we are studying in the Mediterranean have not been systematically surveyed," said Angela D'Amico of the Navy's Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific, and co-principal investigator on the MED 09 project.

International Participants in MED 09

THE PASSIVE ACOUSTIC package for MED 09 was provided by The Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA). Based out of the University of Pavia, Italy, the CIBRA system was developed under the lead of Gianni Pavan, who pioneered the digital recording of sea-mammal sounds in the early 1980s, and was one of the first to recognize patterns of clicks in observed recordings of whales. To read more about CIBRA and their work, visit www.unipv.it/cibra.

Leaders of the two visual observer groups (one from each phase of the sea test), were Dr. Ana Canadas, of the Alnitak Marine Research Center of Spain, and Michela Podesta, Curator of the Vertebrate Department of the Museo di Storia Naturale di Milano (Natural History Museum in Milan, Italy). The Alnitak Marine Research Center focuses on collecting baseline scientific data for a variety of uses. During the last several years, the organization has been involved in the development of conservation plans and the design of Marine Protected Areas, based on robust scientific data.

The Museo di Storia Naturale di Milano houses Italy's most comprehensive overview of the history of life on planet Earth.

Researchers in small, inflatable boats attempted to affix tags to the whales.
U.S. National Marine Fisheries Service permit number 14241 issued to Peter Tyack

The area was chosen because the AUTEC range in the Bahamas, despite its advantages, features considerable levels of sonar sound, meaning that whales in the area may not respond to sonar in the same way as naive animals. A new site was needed where such sounds are less prevalent. The Alboran Sea was selected as the primary MED 09 test area as it provided an area where sonar use was expected to be infrequent and there was a high density of Cuvier's beaked whales, based on the Sirena observations made in 2008. The association of mass strandings of Cuvier's beaked whales and offshore naval maneuvers was first noted in 1991. (For more information, see Simmonds, M. P., & Lopez-Jurado, L. F. (1991). Whales and the military. *Nature*, pages 351, 448.) Subsequently, there had been other stranding events involving this species associated with naval maneuvers in the Mediterranean Sea and other areas. (For more information, see Cox, T. M. et al (2006): Understanding the Impacts of Anthropogenic Sound on Beaked Whales. *Journal of Cetacean Research and Management*, 7(3), pages 177-187.)These factors all contributed to the selection of the Mediterranean Sea for the 2009 trial. Researchers believe a better understanding of the basic biology, normal uses of sound communication and the effects of human sounds on beaked whales will allow for improved protection of the species.

Among the primary objectives of the study were tracking and tagging of several cetacean species, controlled exposure experiments using different sounds, monitoring of ambient noise in areas of variable human interaction, and environmental measurements to support habitat modeling.

Visual observers use the WILD system on the ship's deck.

Visual observers spent a total of 172 hours actively scanning for marine mammals.

According to D'Amico, MED 09 demonstrated the effectiveness of a highly integrated research team to track beaked whales passive acoustic monitoring tools with listening equipment located on a research vessel rather than attached to the ocean floor, as is the case on Navy ranges. Researchers say their ability to listen for the sounds of marine mammals and integrate these measurements with specialized visual monitoring outside of Navy ranges will enhance future studies in areas not equipped with bottom-mounted listening devices.

To collect the data, researchers integrate observations made by highly trained visual observers who observe the animals at the surface, and advanced listening technologies such as towed hydrophones (waterproof microphones) and buoys with deep water hydrophones to track animals when they are vocalizing underwater.

To visualize the locations of the focal animals, a geo-spatial logging and mapping tool, known as Whale Identification Logging and Display (WILD) was used for the first time during the MED 09 trials. Over the course of the sea trial, the WILD system proved its value by becoming a crucial tactical decision aid for the researchers. The WILD Mapper was running in three locations on the ship, providing ship's navigation, observations, both visual and acoustic, and the different teams with their own custom view of the events as they unfold. The team was able to use this capability to help them predict where the beaked whales would resurface after foraging dives and position the vessels accordingly. MED 09 marked the first fully integrated use of the WILD system, integrating data from many different sources. (See our sidebar for more information about the WILD system and passive acoustic monitoring tools.)

Once a desirable group of animals was identified, researchers maneuvered their primary ship, the NATO research vessel Alliance, toward the focal animals. The WILD system was then used to estimate the location of the next surfacing of the whale so that the Alliance could deploy a small, quiet tagging boat, allowing researchers to get close enough to attempt to affix monitoring tags to the animals.

Beaked whales are notoriously difficult to observe, track, and tag. They can dive up to two kilometers and stay underwater for over an hour. When they do momentarily surface, usually for just a few minutes at a time, their low profile makes them nearly invisible in anything but the calmest ocean conditions.

The WILD System

THE WILD SYSTEM was developed by the Space and Naval Warfare Systems Center Pacific, to support marine mammal research. The system was based on the concept, developed by the NATO Undersea Research Centre, of using Geographic Information System (GIS) for real time data logging of marine mammal sightings. The WILD system has expanded the concept with the integration of sightings of marine mammals by trained visual observers, detections by passive acoustic arrays and other hydrophone systems and the positions of research vessels on a graphical display in real time.

Each data source broadcasts its observations through the ship's network in data sentences. These sentences are integrated into a single feed which is rendered by the WILD Mapper application anywhere on the ship. The WILD Mapper utilizes the ArcGIS ® desktop GIS to display the marine mammal observations and vessels along with any necessary background information such as bathymetry, nautical charts and other contextual information. The WILD system can also be deployed as a standalone system with its own network and Global Positioning System for smaller research vessels.

Future upgrades to the WILD system include predictive models of whale surfacings, three-dimensional displays, and integration of other sensor systems used in marine mammal research. In addition, the WILD system has the potential for use in similar applications, such as avian and terrestrial animal research.

The elusive nature of beaked whales combined with unfavorable weather made it impossible to attach monitoring tags to the animals during MED 09. Though researchers were disappointed to leave without tagging a beaked whale, they say that the cruise did succeed in its goal of repeated detection and extended focal follows of Cuvier's beaked whales. This was critical for current ongoing experimental procedures, which require the ability to hear when whales stop vocalizing, an indication of when to cease transmissions during controlled exposure experiments.

"We have made major strides in refining the tools and technologies for conducting vessel-based controlled exposure studies of beaked whales, as well as significant contributions in terms of basic biology and behavior," said Brandon Southall, senior scientist at Southall Environmental Associates

Bioacousticians monitoring the sounds received on the hydrophones which have been translated into spectrograms.

Rough weather conditions on many occasions made the whale tagging process impossible.

and co-principal investigator on the MED 09 project. "These advances and… complementary approaches will be useful not only with regard to future naval operations in the Mediterranean Sea, but also in constructing sound exposure models for military exercises in other areas and informing mitigation methods. This is cutting edge science, and we are pushing the boundaries of what is possible in studying some of the most reclusive animals on earth."

D'Amico agrees. "Collectively, we are contributing to the understanding of

For More Information

FOR MORE ABOUT the benefits of training with active sonar, see our story entitled "Training With Active Sonar While Protecting Marine Life" in the spring 2008 issue of *Currents*.

For more information about the complex topic of sound in the sea, visit the Discovery of Sound in the Sea web site at www.dosits.org.

key species that live in the Mediterranean Sea such as Cuvier's beaked whales. With the supporting environmental data we collected in different areas, we are beginning to develop an understanding of the habitat in which they live," she said.

Peter Tyack, Director of Woods Hole Oceanographic Institution's Marine Mammal Center for Research and Conservation was the third co-principal investigator on the MED 09 project. The remaining critical piece of research is to determine the exposures that change normal behavior of the Cuvier's beaked whale in areas where they are at risk of stranding, and to define what kinds of exposure are safe for them.

Primary sponsors of the MED 09 project included the Office of Naval Research, the Chief of Naval Operations Environmental Readiness Division, the Strategic Environmental Research and Development Program, and the National Oceanographic and Atmospheric Administration (NOAA). For a full list of organizations and to read the MED 09 blog, visit http://med09-expedition.blogspot.com.

What's Next in Behavioral Research

In the Navy's ongoing attempts to understand marine mammals' behavioral responses to sound, including military sonar transmissions, the next Behavioral Response Study is planned to start in late summer 2010 in the waters off of Southern California. Known as SOCAL 10, this project is attempting to expand on the successes from the Bahamas and Mediterranean projects in studying marine mammals, with some focus on beaked whales and other deep-diving marine mammals. It is being carefully integrated with other Navy-funded research in southern California, including opportunistic monitoring of marine mammals using listening sensors during active sonar training exercises, and will expand to include some other marine mammal species (like large whales and seals/sea lions) that have not previously been used, but that are important to understand in terms of potential impacts from military training operations. It is intended to include real operational sources during the five-year period in which it will occur. SOCAL-10, like the behavioral response study efforts in the Bahamas, represents a partnership between Navy, NOAA, and researchers from both the private and academic sectors. The experiment will be done with careful precautions to ensure safe and ethical completion of studies while obtaining much-needed data to inform conservation management and the planning of military training operations involving sound. Extensive outreach efforts with local educational, environmental and conservation management groups are planned in an effort to ensure transparency in both the processes and the findings of SOCAL-10.

The ultimate goal of the behavioral response studies, which are being

The Basics About Passive & Active Sonar

A KEY PART of keeping our nation safe relies on the ability to detect the presence of submarines off our coasts. To this end, the Navy relies on the regular use of passive and active acoustics.

Passive acoustics, as the name implies, relies on a system of underwater microphones known as hydrophones that record underwater sounds, including those made by traditional submarines. The Navy has placed hydrophones on the seafloor in strategic areas of the continental shelf in the North Pacific Ocean and North Atlantic Ocean. These fixed hydrophones are capable of locating a submarine within a radius of 50 nautical miles or less. Hydrophones may also be placed on buoys known as sonobuoys. These have the advantage of being able to be dropped from an airplane, and can be placed relatively anywhere in the ocean. An array of hydrophones may also be towed behind a moving ship. Because they are not in a fixed position, the towed system greatly increases the area where submarines can be found. In addition, U.S. submarines themselves are equipped with passive sonar systems that are used to detect and determine the relative position of enemy submarines.

The Navy can also use active acoustics to find submarines. By actively transmitting a sound pulse, an operator can then analyze the echoes that return from objects hit by the sound. They can also measure the time it takes for echoes to return and calculate the distance to the object causing the echo. Much research has been done on classifying the kinds of echoes that different objects make.

The use of active sonar has grown in recent years as enemy submarines have become quieter and more difficult to detect with passive sonar. By using specialized sound transmissions and echo location, active sonar increases the distance at which submarines can be detected and tracked.

The Navy's research is contributing to the understanding of key species such as Cuvier's beaked whales.
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integrated with opportunistic measurements around sonar training exercises, is to understand the initial steps in the chain of events that lead from sound exposure to atypical mass strandings of beaked whales; and to use that understanding to identify a safe response that can be used to indicate risk. The exposures are and will be carefully controlled and measured on the subjects using sophisticated acoustic tags to make it possible to titrate what acoustic exposure leads to an indicator response. The movements and acoustic behavior of the subjects are monitored in real-time with a passive hydrophone array.

In addition to expanding the research to more and different types of marine mammals, the goals of these studies going forward will be to tag more whales in order to obtain a higher statistical sample.

According to Dave Moretti, Principal Investigator for the Navy's Marine Mammal program in the Bahamas, the ultimate goal of the Behavioral Response Studies is to produce a model of animal behavior relative to active sonar. "If this effort is successful," he says, "perhaps it will lay the groundwork for a tool that planners could use in advance of exercises to predict if there's going to be a problem and to take appropriate steps or choose different sites to avoid such a problem."

Discovering the truth about sonar/marine mammal interaction, and learning how to avoid potential interactions with marine mammals will allow the Navy to continue crucial training exercises with active sonar for years to come. ⚓

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