



Humpback whales.



Pacific Fleet Supports

RANGE CAPABILITY

through **MARINE SPECIES**

Monitoring

**Passive Acoustic Monitoring
& Tagging on Hawaii Range Complex
Helps Safeguard Training & Advances Science**

The Navy continues to be a world leader in marine mammal research. Much of this research has focused on underwater detection and tracking of marine mammals; marine mammal behavioral responses to sound; establishing hearing thresholds; determining species location and abundance; and mitigating the effects of underwater sound.

The Navy commits funding in these areas to assist environmental planners, range operators, regulatory agencies, and other stakeholders in making informed decisions as part of the permitting process for Navy at-sea training and testing activities. As the vast majority of these activities take place on ranges, the Navy commits significant funding and manpower to improve understanding of the behavior and abundance of marine mammals within and in near proximity to these areas.

Ongoing efforts by personnel from Commander, U.S. Pacific Fleet (CPF) in the Navy's Hawaii Range Complex (HRC) demonstrate the extent and complexity of the Navy's commitment to this area of scientific research. A combination of contracted and in-house research and monitoring efforts help to ensure the Navy's ability to conduct training and testing activities on HRC while protecting the well-being of marine mammals that inhabit and transit through the range.

The science derived from this monitoring also informs steps taken by commanders to minimize potential effects on marine mammals during training and testing events that involve sonar.

BACKGROUND

The U.S. Navy recently received renewed Marine Mammal Protection Act/Endangered Species Act (MMPA/ESA) permits for at-sea activities in HRC and elsewhere where the Navy has training/testing ranges and operating areas.

These activities are designed to prepare ships, submarines, aircraft and Sailors to perform the Navy's national security mission, which—as an organization that operates forward at sea 24 hours a day, seven days a week—means Navy personnel and systems are constantly interacting with the ocean environment. The original ("Phase I") permits under which Navy training and testing activities take place in these areas began to expire in January 2014, making it vital that the new ("Phase II") permits for 2014–2019 be in place prior to that time.



The Navy has made a significant investment for this purpose, committing more than \$250 million to marine mammal research and monitoring projects during the past decade.

The Chief of Naval Operations Energy and Environmental Readiness Division (OPNAV N45), CPF, U.S. Fleet Forces Command, System Commands (SYSCOM), Naval Facilities Engineering Command (NAVFAC), and Secretariat staff coordinate with environmental regulatory agencies, including the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), to ensure that environmental planning for the Hawaii-Southern California Training and Testing (HSTT) area, including HRC, and the Atlantic Fleet Training and Testing (AFTT) area remains on track.

As part of this planning process, the Navy is required to analyze the effects of its activities on the environment. Because the Navy's proposed sonar, explosives, gunnery, missile, and torpedo use,



Sperm whale.



Spinner dolphin off Kaula.

along with other training and testing actions, have the potential to impact marine life, the Navy and regulatory agencies require scientific data on how those systems affect animals that may be present in and around training and testing areas. The Navy began funding research to obtain such data in the mid-1990s, and data from that research has consistently been incorporated into its National Environmental Policy Act documentation, including environmental impact statements (EIS), used for analysis, and considered by the regulators as part of the permitting process.

The Navy strives to be good stewards of the environment both at sea and ashore. To address this responsibly, the Navy incorporates scientific data into its analysis of potential effects. The Navy has made a significant

investment for this purpose, committing more than \$250 million to marine mammal research and monitoring projects during the past decade. The results of these research efforts, which range from defining hearing thresholds for marine species and using and improving radio tagging for tracking marine mammal movement and physiology, to creating more accurate mathematical models for predicting how marine mammals perceive sound, have contributed greatly to the understanding of how human activities may affect marine life.

In an attempt to expand the available science on marine mammals and address specific regulatory requirements, CPF and NAVFAC personnel, along with professional colleagues from academia and the private

sector, have orchestrated a comprehensive marine species monitoring program under their five-year letter of authorization (LOA) from NMFS for at-sea training in the HRC. The following is a summary of the results of those monitoring efforts, highlights of the lessons learned, and insights into the recommended changes to future monitoring approaches.

COMMANDER, U.S. PACIFIC FLEET

The world's largest fleet command, the U.S. Pacific Fleet, encompasses 100 million square miles, more than half the Earth's surface. The U.S. Pacific Fleet area of responsibility in the Indo-Asia-Pacific region stretches from Antarctica to the Arctic Circle and from the west coast of the United States into the Indian Ocean. The U.S. Pacific Fleet consists of approximately

THE NAVY'S Marine Species Monitoring Program Web Site

The Navy's marine species monitoring program website serves as an online portal for information on the background, history, and progress of the program. The website also provides access to reports, documentation, data, and updates on current monitoring projects and initiatives. The "Reading Room" provides unrestricted access to many of the reference resources listed in the Comprehensive Exercise and Marine Species Monitoring Report for the U.S. Navy's Hawaii Range Complex.

Among the references available via this website are the 2012 Atlantic Baseline Monitoring Report, the Passive Acoustic Monitoring Report for the Jacksonville Range Complex, and a draft of the Navy's Strategic Planning Process for Marine Species Monitoring.

Visit www.navymarinespeciesmonitoring.us for more information.



200 ships and submarines, nearly 1,100 aircraft, and more than 140,000 Sailors and civilians.

The Navy's history in the Pacific spans more than a century and a half. Through the years, the U.S. Pacific Fleet commander's vision, mission and guiding principles have evolved as its challenges have changed. It is the mission of the U.S. Pacific Fleet to protect and defend the maritime interests of the United States in the Indo-Asia-Pacific region. By providing combat-ready naval forces and operating forward in global areas of consequence, CPF enhances stability, promotes maritime security and freedom of the seas, defends the homeland, deters aggression and when necessary, conducts decisive combat action against the enemy. In support of Pacific Command's Theater Campaign Plan, CPF will continue to work alongside their fellow Pacific Command Component Commanders to accomplish Pacific Command's mission. They will collaborate and partner with U.S. Fleet Forces Command to ensure optimum warfighting capacity and capability. CPF is ready and able to execute their mission in the Indo-Asia-Pacific and around the world.

The Navy needs to train and test in a variety of ocean environments, including littoral areas (near shore or shallow water) and the open ocean, to be prepared for deployment. Ensuring Navy personnel are prepared to go into harm's way requires rigorous, real-life training and testing in the air, on land and at sea. The Navy

uses designated air, land and ocean areas where Sailors can safely train with aircraft, vessels and sophisticated systems such as weapons, sensors and related equipment. In these designated areas, the Navy can practice in real-life situations and provide feedback on how well personnel perform.

Conducting testing activities in varying marine environments and in simulated war-fighting environments allows for accurate evaluation of system capabilities.

Test ranges provide facilities and capabilities to support Navy research, development, test and evaluation activities. Conducting testing activities in varying marine environments, such as differing water depths, seafloor types, salinity levels and other ocean conditions, and in simulated war-fighting environments allows for accurate evaluation of system capabilities.



Minke whale.

America's rebalance of forces to meet growing challenges in the Indo-Asia-Pacific makes training and testing in the U.S. Pacific Fleet area of responsibility all the more important. The U.S. Pacific Fleet has six major domestic range complexes where that training and testing occurs.

Southern California

Southern California contains the most capable and heavily used concentration of Navy ranges in the eastern Pacific Ocean. The Navy's ranges in the Southern California (SOCAL) Range Complex are essential for anti-submarine warfare (ASW) training conducted in littoral areas. The waters off SOCAL also provide realistic envi-



Hawaii Range Complex.

Hawaii Range Complex

Hawaii serves as an ideal training location for units deploying from the West Coast to the Western Pacific Ocean or Southwest Asia. Range capabilities in Hawaii provide an opportunity for deploying units to train in multiple warfare areas. The large training area available within the HRC allows training to take place on a geographic scale that replicates potential real world events. There are also large remote areas within the range complex that provide ideal settings for long-distance tests and multinational exercises, such as the biennial Rim of the Pacific training exercise. The HRC includes more than 235,000 square nautical miles of the Hawaii Operating Area (including the Pacific Missile Range Facility (PMRF)).

Mariana Islands Range Complex

Located in the Western Pacific, the Mariana Islands Range Complex (MIRC) encompasses more than 500,000 square nautical miles of ocean around Guam and the Common-



Southern California Range Complex.

ronmental conditions for air, surface, subsurface and amphibious training and testing activities. The SOCAL Range Complex is situated off the coast of Southern California, generally between Dana Point and San Diego, and extends more than 600 nautical miles southwest into the Pacific Ocean. The SOCAL Range Complex encompasses over 120,000 square nautical miles of sea space and includes San Clemente Island.

wealth of the Northern Mariana Islands. The MIRC serves as the principal U.S. military training and basing venue in the Western Pacific, with the unique capability and capacity to support required current, emerging, and future training. Because of its proximity to forward-deployed forces in the Western Pacific, it provides the most economical location for forward-deployed U.S. forces to train.



Northwest Training Range Complex.

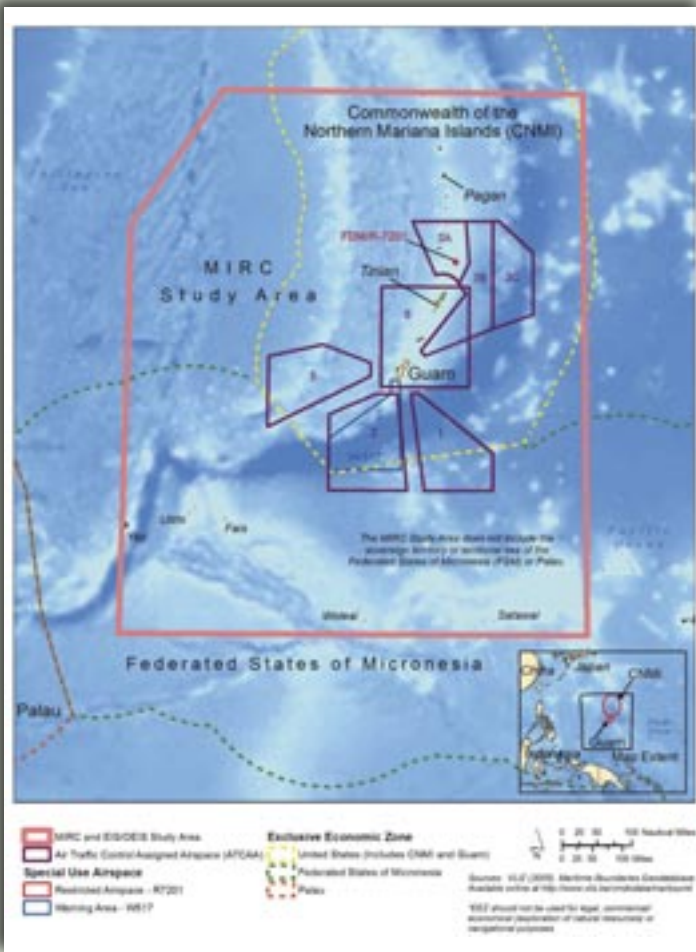
including Puget Sound. The Inshore Area extends east to Idaho, but does not include Oregon or California.

Keyport Range Complex

The Keyport Range Complex is in the Pacific Northwest, providing protected, deep, and secure marine waters for testing, ASW, undersea warfare, and mine warfare. It provides a full spectrum research, development, test and evaluation, engineering, and fleet support center for



Keyport Range Complex.



Mariana Islands Range Complex.

Northwest Training Range Complex

The Navy historically has used areas in the Pacific Northwest for training and testing activities, some dating back to 1914. The Northwest Training Range Complex (NWTRC) consists of two primary components: the Offshore Area and the Inshore Area. The at-sea portion of the NWTRC extends 250 nautical miles from the shores of Washington, Oregon and Northern California, encompassing more than 120,000 square nautical miles. The Inshore Area of the range complex includes all air, land, sea and undersea ranges and operating areas inland of the coastline,

submarines, autonomous underwater systems, and offensive and defensive weapon systems associated with undersea warfare. Four sites make up the Keyport Range Complex, including Keyport Range, Dabob Bay Range Complex, Quinault Range, and Canadian Forces Maritime Experimental and Test Range. All sites provide variable oceanographic properties in marine waters to a depth of 1,200 feet. This variation allows sequentially more challenging environments for testing from sheltered and inland marine waters to open-ocean and surf zone. Naval Undersea Warfare Center Division, Keyport provides recovery of all systems for reuse and analysis at all these sites.

Gulf of Alaska

The Navy trains a few weeks each year in the Gulf of Alaska (GOA) to prepare Sailors and other military personnel for global conflicts and homeland defense/homeland security activities. The Alaska training occurs primarily in the 42,146 square nautical miles of the

Temporary Maritime Activity Area. Complex oceanographic conditions there create a challenging environment for ASW training. The location, size and unique environment of the Alaska Training Areas provide the Navy with a wide range of training opportunities with varying degrees of complexity and diversity, all of which enhance the quality of military training.

The U.S. Pacific Fleet staff reports administratively to the Chief of Naval Operations and operationally to the U.S. Pacific Command, headquartered at nearby Camp H.M. Smith. Commands that fall directly under the U.S. Pacific Fleet include “type” commands for surface ships, submarines and aircraft as well as Navy expeditionary and construction. Operational commands that report directly to the U.S. Pacific Fleet include Third Fleet in the Eastern Pacific and Seventh Fleet in the Western Pacific and Indian Ocean.

For more information about the U.S. Pacific Fleet, visit www.cpf.navy.mil.

MARINE MAMMAL MONITORING & RESEARCH IN THE HRC

Navy monitoring of marine mammals and sea turtles around Hawaii has produced solid scientific results and important lessons in monitoring methods. “Monitoring on the HRC is primarily focused on training events,” said Julie Rivers, CPF’s natural and marine resources program manager. “In addition, we’ve capitalized on the hydrophones at PMRF for our projects.”

The HRC encompasses more than 200,000 square nautical miles of surface and subsurface ocean areas around the main Hawaiian Islands and is home to 24 species of whales and dolphins and one seal species. The Navy has conducted diverse monitoring activities in the HRC, greatly expanding the body of knowledge on marine species distribution, habitat use and behavior.

The Navy’s marine species monitoring approach has evolved as past efforts demonstrated what various monitoring methods can and cannot reasonably achieve. Generally speaking, four “platforms” have been used to collect monitoring data in the HRC: aircraft, surface vessels, data tags (satellite and cell phone) and passive acoustic monitoring (PAM) devices.

The timeline on the following pages is a graphical representation of progression of monitoring efforts and related events in HRC from 2005 to 2013.



Gulf of Alaska.



Bottlenose dolphin.

2005

Vessel/Shore Surveys

Pilot study: Sailboat survey for deep diving cetaceans off Oahu, Kauai & Niihau

- *Notable sighting: Minke whale observed southwest of Kauai*

Acoustic Surveys

Sailboat survey for deep diving cetaceans off Oahu, Kauai & Niihau

- *Minke whales acoustically localized on Pacific Missile Range Facility (PMRF)*

2006

Aerial Surveys

Surveys of channels between Kauai & Niihau and Hawaii Island & Maui during Rim of the Pacific (RIMPAC)

Vessel/Shore Surveys

Shore surveys from Kauai & Hawaii Island during RIMPAC

- *Notable sighting: Leatherback turtle near Hawaii Island*

Acoustic Surveys

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

2007

Aerial Surveys

Surveys off Oahu and Molokai during Submarine Commanders Course (SCC) & Undersea Warfare Exercises (USWEX)

Vessel/Shore Surveys

Sailboat survey off Oahu, Molokai, Lanai, Maui, & Hawaii Island

Vessel survey off Oahu and Molokai during USWEX

- *Notable sightings: Sei whales and Bryde's whale*

Acoustic Surveys

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

2008

Aerial Surveys

Surveys south of main Hawaiian Islands during USWEX

Survey off Kauai & Niihau during RIMPAC

Survey south of main Hawaiian Islands during SCC

- *New technique: Orbital survey accompanying Navy vessel*

2008 CONTINUED

Vessel/Shore Surveys

Vessel survey off Kauai & Niihau during RIMPAC

Acoustic Surveys

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

2009

Aerial Surveys

Survey off Kauai & Niihau during SCC (2x)

Survey off Oahu during Unit Level Training (ULT) & underwater detonation (UNDET)

Vessel/Shore Surveys

Large vessel survey of Hawaiian waters (National Marine Fisheries Service (NMFS))

Marine Mammal Observers (MMO) on Navy vessel during SCC (2x)

UNDET monitoring

- *First monitoring of UNDET in HRC on Pu'uloa Range*

Vessel survey Kaula Islet

Acoustic Surveys

Large vessel survey of Hawaiian waters (NMFS)

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

2010

Aerial Surveys

Survey during SCC

Sinking exercises during RIMPAC

Coastline survey during Koa Kai

Vessel/Shore Surveys

MMOs on Navy vessel during ULT, SCC & Koa Kai

- *New study: Navy lookout effectiveness study initiated*
- *Notable sighting: Fin whale observed by ONR contractor*

Vessel survey Kaula Islet

UNDET

Vessel survey off Kauai & Niihau during RIMPAC

- *First monitoring task order under the HDR monitoring IDIQ contract*

Vessel survey south of main Hawaiian Islands during Koa Kai

- *Notable sighting: Sei whale near Perret Seamount*

Tagging

Hawaiian monk seals tagged on Kauai, Oahu, & Molokai

2010 CONTINUED

Acoustic Surveys

Passive Acoustic Monitoring (PAM) before & after SCC

Two Ecological Acoustic Recorders (EAR) deployed off Puuloa UNDET range (Oahu)

Two EARs deployed off Niihau

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

2011

Aerial Surveys

Surveys during SCC & USWEX

Vessel/Shore Surveys

MMOs on Navy vessel during SCC, USWEX & Koa Kai

Vessel survey Kaula Islet & Kauai

Vessel survey Kaula Islet

UNDET (3x)

- *Notable sighting: Monk seal eating large fish*

Tagging

Hawaiian monk seals tagged on Kauai, Oahu & Molokai

Tagging Kaula Islet & Kauai

Tagging PMRF

- *Notable sighting: Killer whales on PMRF*
- *First tags ever deployed on rough-toothed dolphins anywhere*

Acoustic Surveys

PAM before, during, & after SCC

Marine Mammal Monitoring on Navy Ranges (M3R) at PMRF

- *First implementation & coordination of M3R system with tagging on PMRF*

EAR deployed near Kaula Islet

Three EARs deployed around Niihau

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

2012

Aerial Surveys

Surveys during & after SCC

Vessel/Shore Surveys

Vessel survey PMRF

- *Notable sighting: Minke whale observed on PMRF*

MMOs on Navy vessel during SCC

Vessel survey Kaula Islet

2012 CONTINUED

Tagging

Tagging PMRF (2x)

- *First visual confirmation of acoustically detected Blainville's beaked whales on PMRF*

Tagging analysis

Monk seal tag analysis

Lanai tagging

- *Notable sighting: Fin whale*

Acoustic Surveys

M3R at PMRF (2x)

EAR deployed near Kaula Islet

Three EARs deployed around Niihau (2x)

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

EAR data analysis

Beaked whale passive acoustic monitoring analysis

2013

Aerial Surveys

Surveys during SCC

High resolution bird surveys at Kaula island for Coastal Zone Management Act compliance

- *Notable sighting: 11 monk seals photographed at Kaula Island*

Vessel/Shore Surveys

MMOs on Navy vessel during SCC

UNDET

- *Notable sighting: Second sighting of monk seal "Rocky" at Puuloa*

Tagging

Tagging PMRF & Lanai (2x)

Tagging analysis

Acoustic Surveys

M3R at PMRF (2x)

Baseline acoustic recording two days a month at PMRF using instrumented hydrophone range

EAR data analysis



False killer whale.



An Ecological Acoustic Recorder (EAR). The actual recording device is inside the tube surrounded by Syntactic foam. This unit was deployed near Kaula island in 2011.

Each of the four monitoring platforms is depicted on a separate timeline within the graphic above. Each platform employs various monitoring methods to collect data on marine species at varying scales of time and space. The platform and methodology are chosen based on monitoring requirements, which are in turn driven by the scientific questions the Navy is striving to answer.

Monitoring Platforms

In the early years, shipboard and aerial visual surveys were the primary methods of data collection. Acoustic monitoring had only been performed for Navy projects using towed hydrophone arrays in conjunction with vessel surveys. In calendar year 2010, the program diversified—tagging commenced with cell phone tags deployed on Hawaiian monk seals and acoustic monitoring used the hydrophone arrays at PMRF as well as autonomous moored recording devices (a model known as the Ecological Acoustic

Recorder (EAR)). (Note: Cell phone tags are line-of-sight radio tags much like FM radio tags or walkie-talkies with a range of 10 to 20 miles. Satellite tags talk to satellites and can send and receive data beyond the 20-mile range of a cell phone tag.) Tagging and acoustic monitoring now provide monitoring data and are relied upon in addition to vessel visual surveys. Over time, aerial visual survey methods have been used less frequently.

Monitoring activities occur before, during and/or after training and testing events on the HRC. Four monitoring platforms and methods, as well as specific efforts during select training events, are described below.

Tagging and acoustic monitoring now provide monitoring data and are relied upon in addition to vessel visual surveys.

Aerial Surveys

Aerial surveys have been used for systematic surveys over the open ocean, shoreline surveys and within elliptical orbits in the path of a Navy warship. Systematic survey patterns can sample the distribution of species across a large area but cannot reveal patterns of species presence over time unless the



Green sea turtle.



A pair of green turtles mating near Pearl Harbor, observed after underwater detonation (UNDET) monitoring on the Puuloa UNDET range.

Morgan Richie

same survey pattern is repeated frequently at short time intervals. Because the timing of monitoring is generally linked to Navy training schedules instead of regular sampling intervals in the HRC, it was determined that regular systematic surveys would not achieve Navy monitoring goals.

The aerial shoreline survey methodology was initially employed to assess whether animals were stranding on remote shorelines following training

events. Although no training event-related strandings were observed, it quickly became clear that aerial shoreline surveys from aircraft provided an efficient method for sampling species that aggregate in shallow water near the coast. In Hawaii, this method has been effective for assessing populations of Hawaiian monk seals on beaches and sea turtles, particularly in areas with sandy bottoms.

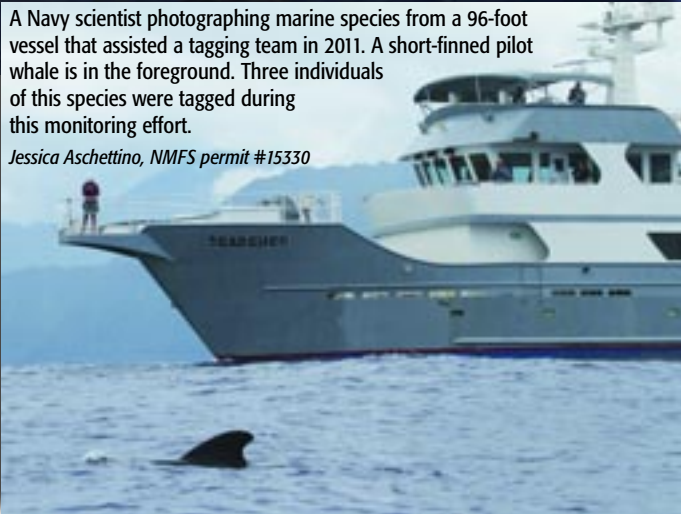
Surveying in an elliptical pattern in the path of a destroyer has only been attempted in the HRC due to the logistical challenges this method presents. Because the volume of commercial and private aviation traffic is relatively low near PMRF, PMRF range controllers are able to direct altitude separation of survey aircraft and Navy aircraft with enough safety margin to make this survey method viable.

During elliptical orbits, an aerial survey team flies in front of a Navy ship that is participating in ASW training and transmitting mid-frequency active sonar (MFAS). The orbits extend from approximately 200 meters in the front of the ship out to approximately 2,500 meters, over a circle with a diameter of 5 kilometers.



A Navy scientist photographing marine species from a 96-foot vessel that assisted a tagging team in 2011. A short-finned pilot whale is in the foreground. Three individuals of this species were tagged during this monitoring effort.

Jessica Aschettino, NMFS permit #15330



Pilot whale.

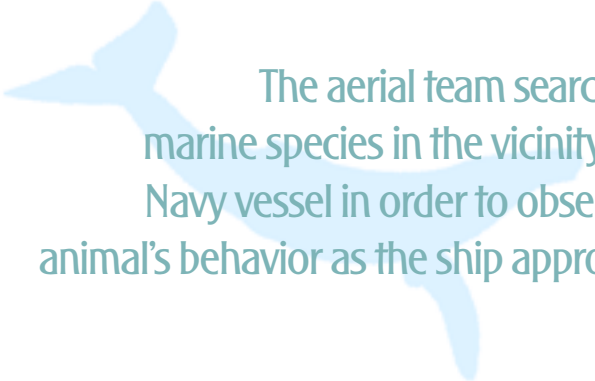
The aerial team searches for marine species in the vicinity of the Navy vessel in order to observe the animal's behavior as the ship approaches and supplies data that would allow acousticians (during subsequent analysis) to estimate the range of sound the animals received (if any) from MFAS.

When a marine mammal or sea turtle is sighted within approximately 5 km (2.7 nautical miles) of a ship involved in a training event, the animal's initial location is noted and the survey plane commences a behavioral focal follow protocol. (Note: A focal follow is the continuous tracking of a specific individual or group to gather a detailed chronology and description of behaviors.) The focal follow session is documented in each case using a high-definition, hand-held video camera with audio input from the airplane's intercom system. The goal is to circle the focal group or animal for as long as possible, documenting each behavior (e.g., blow, breach, fluke-up dive). Videos are later transcribed with time stamps for each event using a behavioral ethogram (a comprehensive inventory of the behavior of the animal).

Surface Vessels

Monitoring from surface vessels takes place on vessels ranging from 19-foot rigid-hull inflatable boats (RHIB) to large Navy warships. During some Navy training events, Marine Mammal Observers (MMO) embark on a Navy surface warship. The MMOs are trained biologists who specialize in identifying species of marine mammals and observing their behaviors. They are separate from Navy lookouts or watchstanders, who are responsible for spotting and reporting all types of surface contacts at sea. During training events that

employ layered monitoring methodologies simultaneously (such as the Submarine Commanders Course (SCC)), MMOs are aboard the same surface ship to which an aerial survey aircraft is assigned. Along with the lookouts, the MMO team helps keep the ship's bridge informed. The observers also relay animal sighting information to the aerial survey team via radio. Observers on both small and large surface vessels can monitor very small areas for changes in marine species presence over short periods of time. Primary goals for small boat surveys have been to gather data on habitat use and movements of marine mammals near PMRF, provide species verification for acoustic detections under the Marine Mammal Monitoring on Navy Ranges (M3R) program, and deploy satellite tags prior to specific training events.



The aerial team searches for marine species in the vicinity of the Navy vessel in order to observe the animal's behavior as the ship approaches.

Monitoring Tags

Tagging is an element of the monitoring program in HRC that allows researchers to generally localize animal movements, in some cases including dive patterns. Satellite tags have been deployed on odontocetes and cell phone tags have been



A breaching juvenile Blainville's beaked whale. This individual breached repeatedly on PMRF near a Navy monitoring vessel in 2012.
Mark Deakos, NMFS permit #14451



Hawaiian monk seal.



Hawaiian monk seal eating a large fish on the Puuloa UNDET range.
Robert Uyeyama

recent efforts over the past decade, this group of animals had not been well-studied. Satellite tag data is greatly increasing the knowledge base on the many species which have now been tagged.

Passive Acoustic Monitoring

PAM involves several different methodologies on HRC, including the instrumented range at PMRF and deployment of long-duration autonomous recorders. The PMRF instrumented range of

West Kauai includes 199 functional bottom-mounted hydrophones arrayed across three water depth categories. The hydrophones record sounds in the environment over hundreds of square miles. The same technology that supports tracking undersea vehicles is well suited to identifying and localizing the clicks and vocalizations of many marine mammals.

In 2012, the range hydrophones at PMRF were further enhanced with the addition of the M3R system, greatly expanding the range's monitoring and research capability. The M3R system processes acoustic signals from the hydrophones, and on-shore acousticians observe and characterize species vocalizations using the M3R system software. When the M3R system was installed, it

deployed on pinnipeds (Hawaiian monk seals). (Note: Odontocetes are dolphins and whales with teeth and include false-killer whales and pilot whales. Mysticetes are whales with baleen and no teeth and include blue whales, right whales and gray whales.)

Cell phone tags are providing new information on the critically endangered Hawaiian monk seal—a species found only in Hawaii and whose population has been declining in recent decades. While the majority of the population (about 900 individuals) resides in the Northwestern Hawaiian Islands, a smaller population of about 200 animals resides in the main Hawaiian Islands. Cell phone tags deployed on several of these individuals have provided important data on these animals' movements in and around the main Hawaiian Islands.

Cetacean tagging efforts in the HRC have focused on odontocete cetaceans, which, with the exception of the seasonally occurring humpback whales, are encountered with much greater regularity than mysticete cetaceans (baleen whales). Despite the presence of 17 species of odontocete cetaceans in and around the HRC, until

The same technology that supports tracking undersea vehicles is well suited to identifying and localizing the clicks and vocalizations of many marine mammals.

provided the additional research potential of localizing a marine mammal that is repeatedly vocalizing within the area of the range. On a limited basis, this utility allows the user to monitor range activity of vocalizing cetaceans and to view spectrograms for hydrophones of interest. (Note: Only



Humpback whale.

submerged and repetitively vocalizing/clicking animals can be localized. A spectrogram is a visual representation of sound showing the frequency, intensity, duration and variation of a sound over time. Using spectrograms, a trained analyst can, in most cases, determine the nature of the received sound.) Because the HRC is much larger than the instrumented PMRF range, the Navy also has collected or obtained analysis of PAM recordings from a number of autonomous buoys at various locations around the main Hawaiian Islands. Analysis of autonomous buoys outside of PMRF provides snapshots of habitat use and species distribution in a given area and at a given depth.

Integrated Comprehensive Monitoring Plan & Implementation

As the timeline shows, the use of four monitoring platforms has evolved over the life of the Navy's monitoring program. It reflects the broader monitoring framework encompassed

within the Navy's Integrated Comprehensive Monitoring Plan (ICMP). That program was developed in direct response to permitting requirements for the Navy's ranges, requirements that are established in Marine Mammal Protection Act (MMPA) final rules and Endangered Species Act (ESA) biological opinions. The four primary objectives of the ICMP are to:

1. Monitor and assess the effects of Navy activities on protected marine species.
2. Ensure that data collected at multiple locations are collected in a manner that allows comparison between and among different geographic locations.
3. Assess the efficacy and practicality of monitoring and mitigation techniques.
4. Add to the overall knowledge base of protected marine species and the effects of Navy activities on these species.

As required under the MMPA, the Navy is responsible for monitoring and reporting on activities involving active sonar and/or detonations from underwater explosives. The ICMP provides the overarching framework for coordination of the Navy's monitoring program. The Navy's ICMP is evaluated through an annual adaptive management meeting where personnel from the Navy and NMFS jointly consider prior year goals, monitoring results, and related scientific advances to determine if modifications are needed to more effectively address monitoring program goals. The Navy and NMFS also consider input from the Marine Mammal Commission as part of this process.

The HRC monitoring plan is a range-specific plan that was created by CPF staff in concert with the ICMP. The annual HRC plans provide guidance for CPF's selection of field methodologies used to satisfy monitoring requirements.

Compliance Monitoring Summary

From 2009 to 2013, CPF maintained compliance with the annual metrics outlined in the HRC monitoring plan and as amended in each annual LOA renewal request. (See the table below for a summary of the evaluation metrics and monitoring efforts from 2009 to 2012 contained in the HRC monitoring plan.)

CPF designed the first HRC monitoring plan (finalized in December 2008) around metrics that required specific quantities of visual survey hours or deploying a specific number of tagging devices per year. The plan was designed to gather data to help address a series of scientific questions posed by NMFS. CPF used this approach through 2013.

Over time it became clear that these metrics were not consistently good indicators of success for monitoring. As an example,

when training events happened under less-than-optimal survey conditions, marine mammal monitoring during those events did not consistently yield useful data. The rigidity of the metrics occasionally led to monitoring during surveys being conducted in poor conditions in order to meet annual monitoring plan commitments.

In February 2009, the Navy and NMFS held the first annual adaptive management meeting as required under the Navy's MMPA/ESA permits. The meeting provided an opportunity to review monitoring results, consider new scientific studies, and discuss lessons learned. As part of the Navy's ICMP, the Navy and NMFS agreed to a set of general research questions which future Navy

MONITORING PLAN METRICS ACCOMPLISHED ANNUALLY

Study Type	2009	2010	2011	2012
Visual Surveys	104 hours aerial during ASW and during three explosives events 40+ hours vessel during ASW and during two explosives events	163.8 hours of aerial and vessel surveys	299.8 hours of aerial and vessel surveys	More than 232 hours of aerial and vessel surveys
Marine Mammal Observers	80 hours during ASW and 40 hours during explosive events	239.3 hours during two ASW events and six explosive events	Three ASW events and four explosive events	Two ASW events and 10 explosive events
Tagging	Tags ordered for Pacific Islands Fisheries Science Center (PIFSC) deployment	11 Hawaiian monk seals tagged	10 Hawaiian monk seals tagged Five attempted tag deployments on cetaceans, four successful Continuing analyses of tag data from Fiscal Year 2010 monitoring	15 attempted tag deployments on cetaceans, 14 successful
Passive Acoustic Monitoring	Contracted for use of four High-frequency Acoustic Recording Packages to be deployed in 2010 Gathered and analyzed data from PMRF instrumented hydrophone range two days per month	Deployed four EARS Funded baseline analysis of archived PIFSC acoustic data Gathered and analyzed data from PMRF instrumented hydrophone range two days per month Prep for early award for analysis of archived EAR data	Deployed four EARS Analyzed archived data from two EARS Gathered and analyzed data from PMRF instrumented hydrophone range in conjunction with SCC plus two days per month	Deployed four EARS and 18 sonobuoys Analyzed data from eight historical EAR deployments Gathered and analyzed data from PMRF instrumented hydrophone range in conjunction with SCC plus two days per month



The first confirmed sighting of a Bryde's whale in Hawaiian waters, north of Oahu in 2007. There are three rostral ridges on this species. Courtesy of CETOS Research Organization, NMFS permit #1039-1699.

monitoring efforts would try to answer. Adaptive management meetings were also held in the fall of 2010, 2011 and 2012.

A series of monitoring meetings in 2010 refined the approach for the Navy's monitoring program. With input from the regulatory agencies and the marine science community, the Navy critically evaluated region-specific monitoring plans as well as the ICMP. As part of that process, the Navy established a Scientific Advisory Group (SAG) of leading marine mammal scientists with the task of developing recommendations for a Navy monitoring strategic plan. In May 2011, the SAG proposed more specific research questions to focus monitoring efforts on filling key data gaps. CPF established a regional SAG for Hawaii in June 2011, and in November 2013 research questions from the regional SAG were integrated into a new regional monitoring plan. With concurrence from NMFS, Navy monitoring on HRC from 2013 forward will use research questions rather than metrics based on visual survey hours and quantities of tags deployed.

Evolution of Methodology & the Submarine Commanders Course

The evolution of the HRC marine species monitoring program is apparent on the visual timeline on pages 16 and 17.



A Sei whale observed north of Oahu in 2007. Courtesy of CETOS Research Organization, NMFS permit #1039-1699.

Until 2010, a major focus of monitoring efforts in HRC was the Rim of the Pacific (RIMPAC) training exercise. The large multinational training event occurs every other year, and several monitoring efforts were scheduled in conjunction with the month-long exercise. But RIMPAC—partly because of its wide geographic footprint and the difficulty of obtaining information from many international participants—did not provide a reliable venue to collect useable data. Consequently, the Navy turned its focus to more dependable regular training events that had also been the subject of some monitoring. The SCC, a multi-unit training event that occurs regularly on PMRF, is an appropriately sized event, consistently scheduled and includes the regular use of mid-frequency active sonar.

The SCC is well-suited for aerial monitoring based upon the number of assets involved and because the surface ship portion occurs at the PMRF instrumented hydrophone range. This event allows for range control to route the aerial survey aircraft away from the Navy P-3s and helicopters to avoid collision.

Multiple platforms and monitoring methods were combined and expanded over the monitoring events from 2009 to 2012. The first SCC monitoring events included aerial surveys, MMOs embarked on a Navy surface ship during the event and acoustic recordings collected from the PMRF hydrophones before and after the event. In 2011, special approval was obtained for collection of acoustic recordings during the event. In 2011 and 2012, cetacean tagging aided by the newly installed M3R system was added to the other methods. Once compiled and analyzed, data from satellite tagged odontocetes had the potential to contribute to monitoring by showing movements of individuals before, during and after training events, and provide further insight with regards to the movements of the animals in relation to active Navy assets. As a result, the layers of monitoring methodologies applied concurrently or near-concurrently included:

- Aerial visual surveys, orbiting in the path of a Navy surface ship conducting ASW training.

Continued on page 28.

Marine Species Research & Monitoring Hierarchy

The Navy's ICMP provides the overarching organizing framework for the Navy's research and monitoring efforts to better understand and monitor the potential impacts of anthropogenic sound on marine species. Those efforts are coordinated among the following programs:

1. The Office of Naval Research's (ONR) Marine Mammals and Biology (MMB) Program
2. The Living Marine Resources (LMR) program sponsored by the Chief of Naval Operations Energy and Environmental Readiness Division (OPNAV N45)
3. The Navy's Fleet-sponsored marine species monitoring programs

THE MARINE MAMMALS AND BIOLOGY PROGRAM

The MMB program is the Navy's basic (6.1) and early applied (6.2) research program on marine mammals and biology and is managed at ONR by Dr. Mike Weise. The MMB program sponsors research to better understand and characterize the potential effects of Navy sound exposure on marine mammals in an effort to minimize disruption to marine mammals and other protected marine life during naval activities. MMB program topic areas include the following:

1. **Monitoring**
Development of resources to monitor and mitigate potentially adverse interactions between naval activities and the marine environment.
2. **Integrated Ecosystems Research**
Investigations of the overall ecology of marine mammals including the development of sensors and tags that can provide the data needed to understand the relationship between marine mammals and their environment.
3. **Effects of Sound**
Investigations of the effects of sound on marine life including understanding how they hear, Behavioral Response Studies (BRS) to understand how anthropogenic sound affects their behavior, understanding their physiology including how they have evolved for diving and how they respond to stress, and what are the population consequences of acoustic disturbance.
4. **Models & Databases for Environmental Compliance**
Investigations into predictive modeling and quantitative risk assessment for anthropogenic sounds in the marine

environment, and other tools to support environmental compliance efforts and decision making.

MMB Principal Investigators include members of the academic community, government laboratories, and private industry. The MMB program works closely with federal, state, and non-U.S. agencies charged with conservation and management of the marine environment to better facilitate the dissemination of program results.

MMB program-developed technologies and/or capabilities that have potential application for the Fleet monitoring programs can be transitioned to the (6.4) LMR program for demonstration and validation, or even directly to the Fleets depending on their specific requirements. For example, the MMB program has invested heavily in persistent, autonomous, passive acoustic monitoring of marine mammals from a variety of platforms that can complement and expand existing legally mandated Fleet monitoring approaches. Also, the MMB program helped to pioneer BRSs, which simultaneously tag whales and expose these animals to low level sonar to better understand and characterize their responses. These responses are the basis for threshold criteria used in all risk assessments for EISs that enable Navy training exercises.

For more information about ONR's MMB program, visit www.onr.navy.mil/en/Science-Technology/Departments/Code-32/All-Programs/Atmosphere-Research-322/Marine-Mammals-Biology.aspx.

THE LIVING MARINE RESOURCES PROGRAM

The Navy's late stage applied research (6.4) LMR program is managed for OPNAV N45 at the Naval Facilities Engineering and Expeditionary Warfare Center by Dr. Bob Gisiner. The 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. This mission is accomplished through the following five primary focus areas:

1. Providing science-based information to support Navy environmental effects assessments for at-sea training and testing.
2. Improving knowledge of the ecology and population dynamics of marine species of concern.
3. Developing the scientific basis for the criteria and thresholds to measure the biological effects of Navy-generated sound.

4. Improving understanding of underwater sound and sound field characterization unique to assessing the biological consequences of underwater sound (as opposed to tactical applications of underwater sound or propagation loss modeling for military communications or tactical applications).
5. Developing technologies and methods to mitigate and monitor environmental consequences to living marine resources resulting from naval activities on at-sea training and testing ranges.

The LMR program is advised by an executive committee, the Living Marine Resources Advisory Committee (LMRAC), made up of representatives from the major Navy stakeholder organizations involved in this environmental issue, including U.S. Fleet Forces, CPF, the Navy Systems Commands (Naval Air Systems Command, Naval Facilities Engineering Command (NAVFAC), Naval Sea Systems Command, Space and Naval Warfare Systems Command), as well as ONR and the Office of the Secretary of the Navy for the Environment. Members of the LMRAC are actively involved in the support of basic research that provides new opportunities for LMR funding (from ONR and elsewhere) and/or they are actively engaged in the application of LMR work products to the preparation of National Environmental Policy Act and related risk analyses related to Navy environmental compliance documentation. LMRAC members are also engaged with the application of LMR new technologies to risk mitigation and monitoring requirements developed adaptively with the appropriate regulatory authority through the Navy's ICMP that is coordinated by OPNAV N45.

An example of such transitions from basic research through applied research and application include the development of hearing-based risk criteria such as Temporary Threshold Shift criteria and hearing weighting functions for different frequencies of sound relevant to Navy sound sources.

Similarly, data about the behavioral responses of marine animals to Navy sound sources are being derived from a methodology pioneered by ONR via the BRS which is currently jointly funded and managed by the MMB and LMR programs, with data transitioning directly to the user community via publication in peer-reviewed scientific literature. The M3R system, a similar project that uses existing acoustically instrumented Navy ranges and is led by personnel from the Naval Undersea Warfare Center in Newport, Rhode Island, was pioneered by ONR and is currently undergoing demonstration and evaluation under LMR support for eventual transition to Fleet ownership as an adjunct to the normal tactical operations of the instrumented ranges.

For more information about the LMR program, visit www.lmr.navy.mil.

THE NAVY'S FLEET-SPONSORED MARINE SPECIES MONITORING PROGRAMS

As part of the regulatory compliance process associated with the MMPA and the ESA, the Navy is responsible for meeting specific requirements for monitoring and reporting on military training activities involving active sonar and underwater detonations from explosives and explosive munitions. The Fleet marine species monitoring program is a direct outcome of MMPA Letters of Authorization issued to the Fleet for each range complex. The Fleet uses CNO's ICMP as an overarching guide, tailoring each range complex monitoring plan specific to regional objectives. Input from local researchers is solicited by NAVFAC for use in development of those objectives which are provided in annual reports to NMFS as well as discussed at an annual adaptive management meeting with NMFS. (See the Navy's marine species monitoring web site at www.navy.marinespeciesmonitoring.us for more information.)

Julie Rivers oversees the marine species monitoring efforts described in this article and in the Mariana Islands Range Complex. Her colleague, Chip Johnson, oversees similar efforts on other Pacific range complexes (including the Southern California, Gulf of Alaska and Northwest Training and Testing ranges). U.S. Fleet Forces Command has a parallel effort for Atlantic monitoring efforts which is managed by Dave MacDuffee. Fleet personnel are ultimately responsible for the proper application of the results from the above mentioned research programs within the operational Navy's monitoring programs. NAVFAC biologists provide subject matter expertise, contracting and project oversight for most of the field efforts.

The Fleet monitoring programs typically use tools that have already been developed under ONR's MMB program and field tested by OPNAV N45's LMR program. For example, most of the autonomous passive acoustic monitoring devices that the Fleet is currently using were developed and tested under R&D funding from ONR. This was followed by years of field deployments and refinements to the devices by the LMR program. The Fleets now use the devices as a regular component of the monitoring program. Additionally, analysis of the acoustic data provided as output from the autonomous devices is conducted using species classifiers developed under the same progression from the MMB program to the LMR program onto the Fleet.

When possible, the Fleet program managers also work closely with the ONR and LMR teams to coordinate field projects where the three programs have overlapping field projects—the combined M3R, tagging, visual/acoustic verification effort conducted in January 2012 at PMRF is one such effort.



Spinner dolphins seen near Kaula island.
Morgan Richie



A Minke whale observed on PMRF in 2012. Note the relatively short rostrum. The white patch on the top surface of the pectoral fin can be seen under the water adjacent to the body.
Mark Deakos, NMFS permit #14451

Continued from page 25.

- MMOs for visual survey embarked aboard the Navy surface ship being followed by the aerial survey.
- Acoustic recordings made during training events by the underwater instrumented range, using M3R assets.
- Satellite tags applied to marine mammals on or near the range before the commencement of the training events.

The results of combining the varied platforms and methodologies during the SCC are summarized below.

Aerial surveys were conducted during five SCC events between 2008 and 2012 using survey, focal follow and video. Eighteen focal follows conducted during those events produced a total of 4.5 hours of video recording. Seventeen of the 18 focal follows (94 percent) occurred during one SCC event in early 2011. Sixteen of the 18 (89 percent) sessions involved humpback whales (*Megaptera novaeangliae*); the remaining two were of spinner dolphins (*Stenella longirostris*) and false killer whales (*Pseudorca crassidens*). Received levels of sound were estimated for four of the 18 (22 percent) focal follows, for which MFAS transmission times and positions of marine mammals and ships were available.

Four of the focal follows involving seven humpback whales overlapped with MFAS transmissions, enabling received levels to be estimated. (Note: Estimated maximum received levels at focal group locations ranged from 135 to 161 decibels (dB) relative to 1 microPascal (μ Pa). Acoustic exposure is estimated as the sound pressure levels in decibels (dB) root mean square relative to 1 μ Pa.) Two sessions involved exposure to a single MFAS transmission, and two involved exposure to multiple sonar transmissions.

Among the sightings were three rarely seen priority species—Blainville’s beaked whale, minke whale, and sperm whale.

It can be challenging to correlate acoustic and visual detections, because acoustic detections are obtained while the animal is underwater and visual observations are only possible when animals are surfacing. The acoustic and visual behaviors during this encounter are still being analyzed, but it may not be possible to determine whether the behaviors observed were in response to the ship, the MFAS transmissions, the presence of other whales nearby, or a combination of these factors.

Acoustic monitoring efforts at HRC evolved significantly from 2009 through 2012. In 2009, acoustic recordings at PMRF were performed two days per month. Each recording provides approximately one day of data from 31 hydrophones. Beaked whale clicks are often detected on hydrophones in the 1,000 m to 2,000 m depth range.

The 2010 analysis effort focused on beaked and minke whales before and after the February SCC, utilizing automated species passive acoustic detection and classification algorithms.

The Navy initiated a more intensive pre-SCC field monitoring effort in 2012. Surveys utilized both a 24-foot (7.3-m) RHIB and, for the first time, a dedicated U.S. Navy vessel—the 225-foot (67-m) ocean tug USNS Sioux. The survey was designed to optimize encounter rates for visual validation of acoustic detections and satellite tagging of species for which population size, habitat use, and movement pattern data are lacking. There were 161 sightings from USNS Sioux and 13 from the RHIB, representing eight confirmed species. Among the sightings were three rarely seen priority species—Blainville’s beaked whale, minke whale, and sperm whale. Acoustic detections of six species were visually confirmed during the combined platform survey, including the first visual confirmation of a Blainville’s beaked whale acoustic detection at PMRF.

BEYOND THE PACIFIC FLEET

Monitoring efforts in the HRC have been conducted in conjunction with training events, and are moving toward a focus on finer scale distributions, movements and behaviors of marine species at locations like the PMRF range. Much more information




Sperm whale.

remains to be collected at larger scales before characterization of the species in the environment can answer broader questions on occurrence and population level effects.

Navy monitoring in the HRC has demonstrated that when a system that can localize marine species in near-real time is combined with deployment of visual platforms to locations where marine species might be localized, sighting rates can be increased. The M3R system has been successful at directing vessel visual surveys to general locations of marine mammals that are continuously vocalizing or clicking. When paired with tagging vessels, the M3R operators have been able to cue tagging vessels to more than 30 percent of their sightings. “In January 2012, the marine resources team (from the Naval Facilities Engineering Command, Pacific) and I embarked upon a large vessel. Working in conjunction with the land-based M3R team and a contracted RHIB, we verified species that can be really challenging to observe, including Blainville’s beaked whales,” said Rivers. These sightings also provide visual verification of acoustic detections, thereby facilitating the development of better algorithms for acoustic classification and detection of marine species.

Another lesson from marine species monitoring in HRC is that more refined scientific questions emerge as patterns from observations are considered. These refinements are exceptionally useful to the Navy’s monitoring program, because better questions will help propel the program toward filling key information gaps and developing new and more useful methodologies.

“The lessons learned from monitoring in HRC through 2012 have provided useful data and knowledge which will enhance Navy monitoring in particular and advance the science of marine mammals overall,” Rivers said.

Within the HRC and beyond, the Navy will continue working closely with federal agencies, science institutions and other partners in the United States and abroad to develop new science to increase understanding and guide decision making in the marine environment. 

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