Comprehensive
Exercise and Marine Species Monitoring Report

for the U.S. Navy's
Hawaii Range Complex
2009–2012

17 June 2013
(revised 23 October 2013)

In Support Of
Letter of Authorization
Under The Marine Mammal Protection Act
For Incidental Harassment of Marine Mammals Resulting From
U.S. Navy Training and Testing Activities
In The Hawaii Range Complex

Comprehensive
Exercise and Marine Species Monitoring Report

For the U.S. Navy's
Hawaii Range Complex

Prepared in Accordance With
50 C.F.R. §216.175(h)

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Executive Summary

This report summarizes the Commander, United States Pacific Fleet marine species monitoring under the 5-year letter of authorization (LOA) for at-sea training in the Hawaii Range Complex (HRC). The period covered in detail by this report is from January 2009 to July 2012. Monitoring activities that took place as early as February 2005 are presented in limited detail to provide context for the development and implementation of the Tactical Training Theater Assessment and Planning (TAP), Phase 1 marine species monitoring program.

Overall, the Navy met or exceeded the required number of monitoring hours and passive acoustic monitoring (PAM) device deployments during the monitoring years summarized in this document. A monitoring year in HRC covers a 12-month period from 1 August in one year to 31 July in the following year, except for the first year (2009), which began in January. Mitigation measures agreed to for the LOA were applied effectively on Navy ships using mid-frequency active sonar (MFAS); there were a total of 18 mitigations for sonar during Major Training Events in the HRC between 8 January 2009 and 1 August 2012. Monitoring and mitigation procedures were applied during the 24 underwater detonation training events that were monitored. No incidents were observed or reported.

To make the progression of monitoring methods in HRC easier to visualize and understand, a detailed timeline of monitoring events and administrative events is included in this report. Events are laid out in a graphical manner, and a corresponding table describing the events accompanies the visual timeline. Upon finalization of the HRC monitoring plan (Department of the Navy 2008), the initiation of TAP, Phase 1 monitoring utilized vessel and aerial visual surveys as the primary methods of data collection. Field methodologies were expanded to include aerial elliptical surveys near Navy vessels deploying MFAS, support for a Lookout Effectiveness study, cell phone tagging of Hawaiian monk seals (*Monachus schauinslandi*), satellite tagging of odontocetes, autonomous passive acoustic monitoring PAM (in addition to recordings from the instrumented underwater range at Pacific Missile Range Facility [PMRF]), and the use of the PMRF range in conjunction with visual survey and satellite tagging. To maximize the return from monitoring efforts, the Navy attempted a sophisticated arrangement of “layering” multiple monitoring methods during a regular February at-sea training event on PMRF. The layered elements included vessel visual surveys, satellite tagging, acoustic monitoring, an aerial surveys team flying standard transect patterns and elliptical orbits near a Navy vessel, and marine mammal observers on Navy vessels. Synergy between the monitoring platforms has proved to be useful, and layering has become a standard practice for Navy monitoring in HRC. In addition, existing data sets not collected during monitoring efforts have been analyzed when the anticipated results were likely to provide

information which was relevant to Navy monitoring. Methodologies are continuing to evolve through lessons learned, Adaptive Management Review (AMR) with National Marine and Fisheries Service (NMFS), and input from the scientific community.

In many cases, monitoring projects will continue past the time of this report as analysis is ongoing. Notable results, discussed in detail in Sections 3.3 through 3.7, have contributed to our greater understanding of the original five study questions of the monitoring program. These results (organized by study question) include:

- Question 1: *Are marine mammals and sea turtles exposed to mid-frequency active sonar, especially at levels associated with adverse effects (i.e., based on NMFS' criteria for behavioral harassment, temporary threshold shift, or permanent threshold shift)? If so, at what levels are they exposed?* Evidence from aerial monitoring, marine mammal observer embarks at PMRF, and estimation of received levels (RLs) definitively established that animals are within distances that would allow sonar to be detected above ambient noise. Estimates from PMRF data products indicate received sound pressure levels (SPLs) from about 115 dB re 1 μPa (decibels referenced to 1 micropascal) to 164 dB re 1 μPa, with a single worst-case scenario of 196.9 dB re 1 μPa, although there is uncertainty in the estimates. Analysis is currently underway to ascertain if a behavioral response, such as respiration rate or direction of travel, is visible in videos collected during focal follows during which RLs could be estimated.

- Question 2: *If marine mammals and sea turtles are exposed to mid-frequency active sonar, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last?* This question remains challenging to address because it requires knowledge of baseline animal distribution and movement across a wide area and multiple time scales, animal movements when MFAS is in use, detailed ship position and MFAS data, and a long enough data collection period to observe a change in distribution after MFAS has ceased. Insufficient analysis has been accomplished so far to make a determination and refinement of the goals of analysis is required and in process.

- Question 3: *If marine mammals and sea turtles are exposed to mid-frequency active sonar, what are their behavioral responses to various levels?* Knowing the behavioral response of marine species to MFAS requires either close observation of animals in the presence of MFAS or devices affixed to the animal that can acquire data on the animals' behavior as MFAS occurs. So far, data sets are small, but there are proposed methods for obtaining more information.

- Question 4: *What are the behavioral responses of marine mammals and sea turtles that are exposed to explosives at specific levels?* Marine mammals and sea turtles have been observed in between sequential explosive events, but none have been observed during detonations. All mitigation has been executed correctly, and animals have not been present to be observed for behavioral changes during events.

- Question 5: *Is the Navy's suite of mitigation measures for mid-frequency active sonar and explosives (e.g., Protective Measures Assessment Protocol and major exercise measures agreed to by the Navy through permitting) effective at avoiding temporary threshold shift, injury, or mortality of marine mammals and sea turtles?* Data from mitigation events that have occurred in HRC during anti-submarine warfare training suggest that mitigations actions have been applied when appropriate. Visual surveys conducted before, during, and after training events have detected zero injuries or mortalities as a result of training. Threshold shift is more difficult to quantify, but analysis of sightings observed aboard DDG, from PMRF range, and from tags and aerial surveys during events is ongoing and cannot be answered definitively at this time.

Important baseline occurrence and habitat use information is another result of monitoring. Cell phone tags affixed to Hawaiian monk seals in the main Hawaiian Islands (MHI) have provided activity budgets which can be used for modeling and estimation purposes. They have shown that typically, Hawaiian monk seals stay in relatively shallow water (less than 600 meters) and within 300 kilometers of shore (although some animals occasionally move farther offshore) and that home ranges are variable in size, but do persist in an area that the Navy has been using for decades (PMRF).

Evidence from satellite tags and photo-identification catalogs suggests that PMRF is an area of range overlap between two (perhaps three) stocks of false killer whales (*Pseudorca crassidens*), one of which is the recently ESA-listed Main Hawaiian Islands (MHI) Insular stock, comprised of approximately 151 individuals (NMFS 2012). It appears that PMRF may be located in the vicinity of the far northwestern limit of that of the MHI Insular stock's range and the southeastern limit of the Northwestern Hawaiian Island stock's range. This presents a question regarding how much the animals utilize the area near PMRF in proportion to the rest of their home range. Evidence from photo-identification combined with results from satellite tags deployed on bottlenose dolphins (*Tursiops truncatus*) and rough-toothed dolphins (*Steno bredanensis*) indicates that there may be resident populations of these species in the vicinity of west Kauai, Niihau, Kaula Islet, and PMRF.

Multiple inputs are influencing the direction of monitoring in HRC including AMR with NMFS, a Strategic Planning Process, and independent input from the scientific community.

Future directions for the monitoring program are outlined in Section 6 and include both: (1) recasting of the original five study questions into a conceptual framework of occurrence, exposure, response, and consequences; and (2) a shift away from effort-based metrics toward a focus on a transparent, question-based method for selecting monitoring methods and evaluating results.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFAST	Atlantic Fleet Active Sonar Training
AMR	Adaptive Management Review
ASW	Anti-submarine Warfare
AUTEC	Atlantic Undersea Test and Evaluation Center
BARSTUR	Barking Sands Tactical Underwater Range
BDA	Battle Damage Assessment
BRS	Behavioral Response Study
BSS	Beaufort sea state
BSURE	Barking Sands Underwater Range Expansion
C.F.R.	Code of Federal Regulations
CG	cruiser (type of Navy vessel)
CRC	Cascadia Research Collective
COMPACFLT	Commander, U.S. Pacific Fleet
dB	decibel(s)
DDG	destroyer (type of Navy vessel)
DiFAR	Directional Frequency Analysis and Ranging
DTAG	Digital Acoustic Recorder Tag
EAR	Ecological Acoustic Recorder
EEZ	Exclusive Economic Zone
EIMS	Environmental Information Management System
ERVS	Extended Range Video System
ESA	Endangered Species Act
ETP	Eastern Tropical Pacific
FFG	frigate (type of Navy vessel)
ft.	feet
FY	Fiscal Year
GPS	global positioning system
HARP	High-frequency Acoustic Recording Package
HDR|EOC	Primary NAVFAC contractor for marine species monitoring contract
HICEAS	Hawaiian Islands Cetacean and Ecosystem Assessment Survey
HIMB	Hawaii Institute of Marine Biology
HRC	Hawaii Range Complex
HST	Hawaii-Aleutian Standard Time
ICMP	Integrated Comprehensive Monitoring Program
kHz	kilohertz
km	kilometer(s)
LIMPET	Low Impact Minimally Percutaneous External-electronics Transmitter
LMR	Living Marine Resources
LO	lookout
LOA	Letter of Authorization
LOE	Lookout Effectiveness
m	meter(s)

M3R	marine mammal monitoring on Navy ranges
MFAS	mid-frequency active sonar
MHI	main Hawaiian Islands
MIRC	Mariana Islands Range Complex
MMB	Marine Mammals and Biology
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
MTE	major training event
NAVFAC	Naval Facilities Engineering Command
Navy	United States Department of the Navy
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NUWC	Naval Undersea Warfare Center
NWHI	Northwestern Hawaiian Islands
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
ONR	Office of Naval Research
OPNAV N45	Chief of Naval Operations Energy and Environmental Readiness Division
P3	a type of Naval aircraft
PAM	passive acoustic monitoring
PCIMAT	personal computer interactive multi-sensor analysis training
PIFSC	Pacific Islands Fisheries Science Center
PMAP	Protective Measures Assessment Protocol
PMRF	Pacific Missile Range Facility
PTS	permanent threshold shift
re 1 μPa	referenced to 1 micropascal
RHIB	rigid-hulled inflatable boat
RIMPAC	Rim of the Pacific training event
RL	received level (of sound)
rms	root mean square
ROCCA	Real-time Odontocete Call Classification Algorithm
ROI	return on investments
rSAG	Regional Scientific Advisory Group
SAG	Scientific Advisory Group
SCC	Submarine Commanders Course
SCORE	Southern California Offshore Range
SD	standard deviation
SINKEX	sinking exercise
SOCAL	Southern California Range Complex
SPAWAR	Space and Naval Warfare Systems Command
SPL	sound pressure level
SPORTS	Sonar Positional Reporting System
SWTR	Shallow Water Training Range
TAP	Tactical Training Theater

	Assessment and Planning
TBD	to be determined
TORPEX	torpedo exercise
TTS	temporary threshold shift
ULT	unit level training
UNDET	underwater detonation
U.S.	United States
USWEX	undersea warfare exercise
XBT	expendable bathythermograph

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1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) developed Range Complex-specific Monitoring Plans under the Navy Monitoring Program to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973. The Commander, U.S. Pacific Fleet (COMPACFLT) and Commander, U.S. Fleet Forces Command marine species monitoring programs are composed of a collection of "range-specific" monitoring plans each developed as part of the MMPA/ESA authorization process. The Fleets individual plans establish specific monitoring requirements for each range complex based on a set of effort-based metrics.

This report describes Navy-funded monitoring within the Navy's Hawaii Range Complex (HRC) conducted between January 2009 and August 2012, based on annual monitoring and exercise reports submitted previously to the National Marine Fisheries Service (NMFS) in accordance with 50 Code of Federal Regulations (C.F.R.) §216.175(e) and 50 C.F.R. §216.175(f). This document is a comprehensive report summarizing to the best extent practical results of these reports, prepared in accordance with 50 C.F.R. §216.175(h). The Navy, per NMFS instruction, submitted an outline of this report to the NMFS on 30 November 2012, and submitted the full draft report on 24 January 2013.

There are six main sections within this report: Introduction, Exercise Report Summary, Compliance Monitoring Summary, Navy Basic and Applied Research Summary, Progress on Monitoring Questions, and Future Directions.

The Exercise Report Summary contains a composite listing and review of marine mammal sightings during major training events (MTEs) within the HRC. The Compliance Monitoring Summary discusses scientific contribution and major results from COMPACFLT funded efforts. Fleet funded compliance monitoring is directly tied to the monitoring objectives from the NMFS authorized Hawaii Range Complex Monitoring Plan (Department of the Navy 2008). The Navy Basic and Applied Research Summary describes other concurrent research projects within Hawaii that either increase scientific knowledge on marine mammal and anthropogenic impacts, or provide for testing and validation of new detection technologies. These projects, while supportive of the conclusions discussed in this report, are not directly tied to permit-required compliance monitoring and therefore have variable temporal and spatial scales. The Progress on Monitoring Questions discusses how various technologies and associate results contribute to the HRC monitoring objectives. Finally, Future Directions describes the Navy's lessons learned and recommendations for follow-on monitoring.

1.1 INTEGRATED COMPREHENSIVE MONITORING PROGRAM

Concurrent with implementation of the initial range-specific monitoring plans, the Navy developed the Integrated Comprehensive Monitoring Program (ICMP) which provides the overarching framework for coordination of the Navy's marine species monitoring (Department of the Navy 2010b). It has been developed in direct response to permitting requirements for U.S. Navy ranges, which are established in the various MMPA Final Rules, ESA Consultations, Biological Opinions, and applicable regulations. As a framework document, the ICMP applies, by regulation, to those activities on ranges and in operating areas for which the U.S. Navy sought and received incidental take authorizations.

The ICMP is intended for use as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. Top priority will always be given to satisfying the mandated legal requirements across all ranges. Once legal requirements are met, any additional monitoring-related research will be planned and prioritized using guidelines outlined by the ICMP, consistent with availability of both funding and scientific resources. As a planning tool, the ICMP is a "living document" and will be updated as needed. The initial area of focus for improving U.S. Navy marine species monitoring in 2011/2012 was on development of a Strategic Plan to be incorporated as a major component of the ICMP to guide investments and help refine specific monitoring actions to more effectively and efficiently address ICMP goals and objectives.

The ICMP is evaluated through the Adaptive Management Review (AMR) process to: (1) assess progress, (2) provide a matrix of goals and objectives for the following year, and (3) make recommendations for refinement and analysis of the monitoring and mitigation techniques. This process includes conducting an annual AMR meeting at which the U.S. Navy and NMFS jointly consider the prior-year goals, monitoring results, and related scientific advances to determine if modifications to monitoring plans are warranted to more effectively address program goals.

Under the ICMP, monitoring measures prescribed in range-specific monitoring plans and U.S. Navy-funded research relating to the effects of U.S. Navy training and testing activities on protected marine species should be designed to accomplish one or more of the following top-level goals as prescribed in the current revision of the ICMP (Department of the Navy 2010b):

(a) An increase in our understanding of the likely occurrence of marine mammals and/or ESA-listed marine species in the vicinity of the action (e.g., presence, abundance, distribution, and/or density of species).

(b) An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals and/or ESA-listed species to any of the potential stressors associated with the action (e.g., sound, explosive detonation, or expended materials), through better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (e.g., sound-source characterization, propagation, and ambient noise levels), (2) the affected species (e.g., life history or dive patterns), (3) the likely co-occurrence of marine mammals and/or ESA-listed marine species with the action (in whole or part), and/or (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and/or ESA listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas).

(c) An increase in our understanding of how individual marine mammals or ESA-listed marine animals respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible; e.g., at what distance or received level [RL]).

(d) An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either:

(1) the long-term fitness and survival of an individual; or (2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival).

(e) An increase in our understanding of the effectiveness of mitigation and monitoring measures, including increasing the probability of detecting marine mammals to better achieve the above goals (through improved technology or methodology), both generally and more specifically within the safety zone (thus allowing for more effective implementation of the mitigation). Improved detection technology will be rigorously and scientifically validated prior to being proposed for mitigation, and should meet practicality considerations (engineering, logistic, and fiscal).

(f) A better understanding and record of the manner in which the authorized entity complies with the MMPA incidental take authorization and ESA incidental take statement.

Chief of Naval Operations Energy and Environmental Readiness Division (OPNAV N45) is responsible for maintaining and updating the ICMP, as necessary, reflecting the results of regulatory agency rulemaking, AMRs, best available science and improved assessment methodologies. This is done as part of the AMR process, in consultation with U.S. Navy technical experts, Fleet Commanders, and Echelon II Commands as appropriate.

1.2 Hawaii Range Complex Monitoring Goals

COMPACFLT's marine species monitoring from 2009 to 2012 in the HRC was designed to address the five monitoring questions (see Section 1.3) outlined in the 2008 HRC monitoring plan (Department of the Navy 2008). These study questions were developed by the Navy and NMFS to research potential adverse affects of Navy anti-submarine warfare (ASW) and underwater detonation (UNDET) training on marine mammals and sea turtles in both Atlantic and Pacific Ocean range complexes. The Navy research and development efforts of OPNAV N45 (currently Living Marine Resources [LMR]) and the Office of Naval Research (ONR), as described in Section 4, were leveraged when overlapping research goals exist.

The Navy and NMFS included an AMR in the MMPA process to allow for incorporation of improvements in the structure, content, and implementation of both the ICMP and HRC monitoring plan. In particular, the intended goals were to refine the process through which specific monitoring methodologies were chosen, as well as to define new architectural components of the monitoring program with which the forward development of the program through AMR could be optimally realized.

The evolution of the HRC monitoring program from 2009 to 2012 was productive in realizing these goals. For example, the collective experiences of conducting monitoring efforts in HRC and other range complexes have been instrumental in the definition of the new strategic planning process of the ICMP. This, and other new directions that as of this writing are currently emerging from the AMR process, are described further in Section 6.

1.3 FIVE MONITORING QUESTIONS

In 2008, the Navy and NMFS developed five monitoring ("study") questions, intended to capture the agencies most prescient questions regarding the potential for Navy training to affect the behavior, fecundity, and distribution of marine species. Those questions were:

1. Are marine mammals and sea turtles exposed to mid-frequency active sonar (MFAS), especially at levels associated with adverse effects (i.e., based on NMFS' criteria for behavioral harassment, temporary threshold shift [TTS], or permanent threshold shift [PTS])? If so, at what levels are they exposed?
2. If marine mammals and sea turtles are exposed to MFAS, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last?
3. If marine mammals and sea turtles are exposed to MFAS, what are their behavioral responses to various levels?
4. What are the behavioral responses of marine mammals and sea turtles that are exposed to explosives at specific levels?
5. Is the Navy's suite of mitigation measures for MFAS and explosives (e.g., Protective Measures Assessment Protocol (PMAP) and major exercise measures agreed to by the Navy through permitting) effective at avoiding TTS, injury, or mortality of marine mammals and sea turtles?

The HRC monitoring plan (Department of the Navy 2008) provided the initial guidance for the U.S. Pacific Fleet's selection of field methodologies used to satisfy its monitoring requirements. The monitoring requirements (e.g., metrics) were specifically designed to enable unambiguous measurement of compliance with the Letter of Authorization (LOA) through the statement of a required level of effort for every item in a list of required monitoring methodologies. These monitoring plan metrics and methodologies are described in Table 3.1-1 in Chapter 3. Section 6.1.1 regarding the AMR process describes a refinement of the above form of the HRC monitoring program through adjustment of the study questions, changing the measurement of the Navy's monitoring compliance to be based upon an evaluation of progress towards answering the study questions, and a deeper iterative integration into the ICMP through its adaptation of a newly defined strategic planning process.

1.4 REFERENCE RESOURCES

Most of the reference resources listed below are located within the "Reading Room" page of the Navy's marine species monitoring website at the following URL:
http://www.navymarinespeciesmonitoring.us/reading-room/

To view content specific to HRC at the above website, expand "Pacific Monitoring Reports," and within that section, expand "Hawaii Range Complex (HRC)."

<u>Annual monitoring and exercise reports:</u>

Note that the 2008 HRC monitoring plan for 2009 is given as a separate download, whereas monitoring plans for subsequent years are included as part of the annual monitoring report. Also, the below links for the annual monitoring reports do not include their appendices which are the final reports from the component monitoring activities. These appendices may also be downloaded at the Navy's marine species monitoring website following the link and instructions above, and are listed by year in the "Hawaii Range Complex (HRC)" section.

December 2008 HRC Monitoring Plan for 2009
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/297/**(Note: Subsequent year monitoring plans are included as part of the annual monitoring report)**

2009 HRC-SOCAL Annual Monitoring Report (includes 2010 HRC Monitoring Plan)
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/174/

2009 HRC-SOCAL Annual Exercise Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/274/

2010 HRC-SOCAL Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/163/

2010 HRC-SOCAL Annual Exercise Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/275/

2011 HRC-SOCAL Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/192/

2011 HRC-SOCAL Annual Exercise Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/276/

2012 HRC Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/283/

2012 SOCAL-HRC Annual Exercise Report
http://www.navymarinespeciesmonitoring.us/files/3613/6787/1891/2011_02Aug_-_2012_01Aug_Annual_Range_Complex_Exercise_Report_HRC-SOCAL.pdf

Other files:

Integrated Comprehensive Monitoring Program Charter (December 2010)
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/83/

Scientific Advisory Group Recommendations Report (May 2011)
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/86/

1.5 MONITORING TEAM AND PERFORMERS

The COMPACFLT HRC monitoring team is comprised of non-Navy civilian academic, government, and contractor scientists along with participation by Navy marine species technical experts.

Aerial and vessel surveys were led and conducted by Cetos Research Organization (Ann Zoidis, Mari Smultea); Marine Mammal Research Consultants (Joe Mobley); HDR, Inc. (various); and in-house Navy marine biologists. Passive acoustic monitoring (PAM) and associated analyses were led by Hawaii Institute for Marine Biology (HIMB) (Whitlow Au, Marc Lammers, Michael Richlen), Space and Naval Warfare Systems Command (SPAWAR), Pacific (Steve Martin), Naval Undersea Warfare Center Newport (NUWC) (Dave Moretti), Biowaves (Tom Norris and Julie Oswald), and Marine Acoustics, Inc. (MAI) (Adam Frankel).Marine Mammal Observers were a mix of Navy civilian marine scientists from multiple Navy commands, and a contractor scientist from HDR, Inc. (Tom Jefferson). Tagging was led by NMFS, Pacific Islands Fisheries Science Center (PIFSC) (Charles Littnan), and Cascadia Research Collective (CRC) (Robin Baird, Daniel Webster).

Specific individuals who conducted field monitoring and/or data analysis in the HRC from 2009 through 2013 include (*alphabetized by affiliation*):

Julie Oswald and Tom Norris (Bio-Waves); Jessica Aschettino, Robin Baird, Tori Cullins, Antoinette Gorgone, Sabre Mahaffy, Brenda Rone, Gregory Schorr, Deron Verbeck and Daniel Webster (CRC); Julie Rivers (COMPACFLT); Jessica Hallman (Hawaii Department of Land and Natural Resources); Whitlow Au, Maria Andujar and Marc Lammers (Hawaii Institute of Marine Biology); Kristen Ampela, Lenisa Blair, Chip Chadbourne, Mark Cotter, Brad Dawe, Jeff Foster, Gregory Fulling, Craig Hawkinson, Thomas Jefferson, Tom Kieckhefer, Tara Leota, Keri Lestyk, Todd McConchie, Aude Pacini, Philip Thorson, and Paula von Weller, (HDR, Inc.); Andrea Bendlin (Joint Institute for Marine and Atmospheric Research); Michele Bane (Kauai Marine Mammal Response Program, National Oceanic and Atmospheric Administration [NOAA]); Jenelle Black, Kate Lomac-McNair, Stu Smith, Andrew Titmus, and Kim Valentine (Marine Mammal Research Consultants); Anurag Kumar (Naval Facilities Engineering Command Atlantic); Thomas Savre (Naval Facilities Engineering Command Hawaii); Andrea Balla-Holden (Naval Facilities Engineering Command Northwest); Meredith Fagan, Justin Fujimoto, Sean Hanser, Stephen Jameson, Frans Juola, Morgan Richie, Jennifer Steele and Kate Winters (Naval Facilities Engineering Command Pacific); Ashley Dilley, Nancy DiMarzio, Amy Farak, Scott Fisher, Susan Jarvis, Elena McCarthy, David Moretti, Ron Morrisey, Thomas Vars, Jessica Ward, and Stephanie Watwood (NUWC); Kenady Wilson (Ocean Associates); Brenda Becker, John Henderson, Charles Littnan, Erin Oleson and Tracy Wurth (Pacific Islands Fisheries Science Center); Thomas Kok (San Diego State University Foundation); Hannah Bassett, Ali Bayless, John Hildebrand, Simone Baumann-Pickering, Lisa Baldwin, Anne Simonis, Marie Roch and Mariana Melcon (Scripps Institution of Oceanography); Karin Forney (Southwest Fisheries Science Center); Timi Adeyemi, Angela D'Amico, Chris Kyburg, Stephen Martin and Roanne Manzano-Roth (SPAWAR, Pacific); Eva-Marie Nosal (University of Hawaii); Len Thomas and Vincent Janik (University of St. Andrews); Michelle Bogarus (U.S. Fish and Wildlife Service); Daniel McSweeney (Wild Whale Research Foundation); Tina Yack (Bio-waves and Southwest Fisheries Science Center); Lee Shannon (Naval Facilities Engineering & Expeditionary Warfare Center); Michael Richlen (Hawaii Institute of Marine Biology and HDR, Inc.); Joseph R. Mobley, Jr. and Aliza J. Milette-Winfree (HDR, Inc. and Marine Mammal Research Consultants); Suzanne Yin (HDR, Inc. and Southwest Fisheries Science Center); Marie Hill (Joint Institute for Marine and Atmospheric Research and Pacific Islands Fisheries Science Center); Robert Uyeyama (Marine Mammal Research Consultants and Naval Facilities Engineering Command Pacific); Alan Ligon (CRC, independent consultant and Joint Institute for Marine and Atmospheric Research); Alexis Rudd (Hawaii Institute of Marine Biology, HDR, Inc. and Marine Mammal Research Consultants); Mark Deakos (HDR, Inc., independent consultant and Marine Mammal Research Consultants).

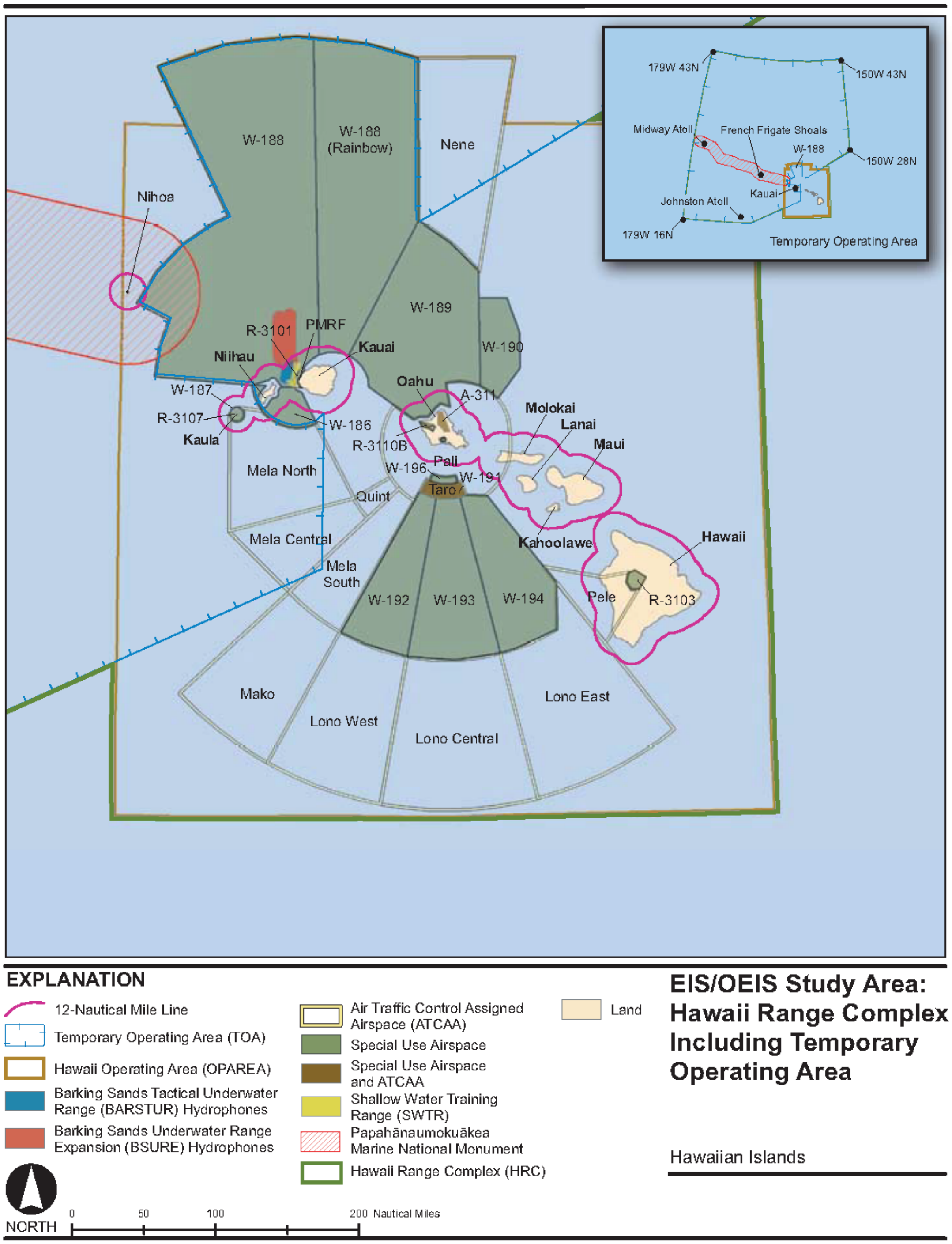


Figure 1.5-1: Hawaii Range Complex Ocean Training Areas

2 HRC MAJOR TRAINING EVENT (MTE) SUMMARY (8 JANUARY 2009 TO 1 AUGUST 2012)

2.1 COMPOSITE LISTING OF HRC MTES

There were 11 individual MTEs that took place in the HRC from 8 January 2009 to 1 August 2012. These MTEs are summarized in Table 2.1-1 below.

Table 2.1-1: Hawaii Range Complex Major Training Exercise Summary

Exercise Type	8 Jan 2009–1 Aug 2009	2 Aug 2009–1 Aug 2010	2 Aug 2010–1 Aug 2011	2 Aug 2011–1 Aug 2012	Reporting Period Total
USWEX	1	1	2	5	9
RIMPAC	0	1	0	1	2
Total	1	2	2	6	11

Notes: RIMPAC = Rim of the Pacific, USWEX = Undersea Warfare Exercise

2.1.1 COMPOSITE LISTING OF HRC MITIGATION EVENTS

There were 18 total mitigation events (MFAS) powered down or shut down due to the sighting of marine mammals or sea turtles during MTEs from 8 January 2009 to 1 August 2012. These mitigation events are summarized in Table 2.1-2. Of these sightings, over 90 percent were observed between 10 and 5,000 yards of the Navy vessel; some were observed by aircraft. The Navy's unclassified annual exercise reports from 2009 through 2012 contain tables listing all marine mammals sighted during that reporting year and the range of the sighting.

Table 2.1-2: Hawaii Range Complex Area Mitigation Events

Marine Animal Species	Range of Detection (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	Mitigation Measure Implemented	Un-required Mitigation (Yes/No)
8 January 2009–1 August 2009			
Whale	500–1,000	Sonar powered down	No
Whale	Not reported	Sonar shut down	Yes
Whale	>2,000	Sonar powered down	No
2 August 2009–1 August 2010			
Dolphin	>2,000	Sonar shut down	Yes
Dolphin	Acoustic detection	Sonar shut down	Yes
2 August 2010–1 August 2011			

Marine Animal Species	Range of Detection (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	Mitigation Measure Implemented	Un-required Mitigation (Yes/No)
Generic	Acoustic detection	Sonar shut down	Yes
Dolphin	500–1,000	Sonar powered down	No
Whale	200–500	Sonar shut down	No
Whale	500–1,000	Sonar shut down	No
Whale	>2,000	Sonar shut down	Yes
2 August 2011–1 August 2012			
Whale	<200	Sonar shut down	No
Whale	500–1,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	>2,000	Sonar shut down	Yes
Dolphin	<200	Sonar shut down	No
Dolphin	<200	Sonar shut down	No
Dolphin	200–500	Sonar powered down	No

2.1.2 Composite Listing of HRC Marine Animal Sightings

There were 192 reported sightings of an estimated 1,225 marine mammals and sea turtles during MTEs in the HRC from 8 January 2009 to 1 August 2012. These sightings are summarized in Table 2.1-3**.**

Table 2.1-3: Hawaii Range Complex Sighted Marine Mammals and Sea Turtles

Marine Animal Types	8 Jan 2009–1 Aug 2009	2 Aug 2009–1 Aug 2010	2 Aug 2010–1 Aug 2011	2 Aug 2011–1 Aug 2012	Reporting Period Total
Estimated Number of Animals Sighted While MFAS Active					
Dolphin	0	3	30	223	256
Whale	3	0	7	18	28
Pinniped	0	0	0	0	0
Turtle	0	0	0	0	0

Generic	1	0	1	3	5
Subtotal while Active	4	3	38	244	289
Estimated Number of Animals Sighted While MFAS Passive					
Dolphin	0	255	6	255	516
Whale	133	34	39	174	380
Pinniped	0	1	0	1	2
Turtle	0	25	0	1	26
Generic	3	4	4	1	12
Subtotal while Passive	136	319	49	432	936
Total	**140**	**322**	**87**	**676**	**1,225**

Note: MFAS = mid-frequency active sonar

2.2 Evaluation of Mitigation Effectiveness

During the 11 MTEs in the HRC from 8 January 2009 to 1 August 2012 (Table 2.1-1), prescribed NMFS mitigation zones were effectively applied in cases of observation of marine mammals and sea turtles within the applicable zone. The three categories of mitigation measures (Personnel Training, Lookout and Watchstander Responsibility, and Operating Procedures) outlined in the HRC Final Environmental Impact Statement/Overseas Environmental Impact Statement of May 2008 and approved by NMFS in subsequent LOAs were effective in appropriately mitigating exposure of sighted marine mammals and sea turtles to sonar. During the entire reporting period, there were zero instances, out of 192 sightings, where a ship neglected to mitigate adequately for a marine mammal sighted by the watchstander team within 1,000 yards. Fleet commanders, aircrews, and ship watch teams continue to improve individual awareness, mitigation execution, and reporting practices. This improvement can be attributed to pre-exercise planning practices, mandatory Marine Species Awareness Training, adherence to required MFAS mitigation zones, and application of lessons learned in marine animal sighting and reporting.

For deep diving animals observed during any MTEs, if exposure did occur, the Navy assesses that these animals would not be exposed to significant levels for long periods based on the moving nature of hull-mounted MFAS use, and even less from less-frequent and lower-power aviation-deployed MFAS systems (dipping sonar, sonobuoys). During a 1-hour dive by a beaked whale or sperm whale (*Physeter macrocephalus*), a MFAS ship moving at a nominal speed of 10 knots could transit up to 10 nautical miles (nm) from its original location, well beyond ranges predicted to have significant exposures.

Table 2.1-2 lists the 18 mitigation events where sonar was active and ships took action to reduce or eliminate inadvertent exposure of marine mammals and sea turtles to sonar. With or without mitigation, given the rapid relative motion of ships maneuvering at sea and the independent marine mammal movement, the time any given animal would be exposed to MFAS from surface ships is likely to be limited. Of the total mitigations listed in Table 2.1-2, seven were conducted in excess of mandated safety zones where ships powered down or shut down sonar at ranges beyond what was required. Although 7 out of 18 total events (39 percent) is a large number of excessive mitigations, the percentage of un-required mitigations for ships in HRC MTEs has been trending downward, with 25 percent of mitigation events being excessive over the past reporting year after 40 percent and 100 percent for the two previous years. This reduction in over-mitigating can be attributed to increased training and familiarity with the mitigation measures, simplification of the measures themselves, and leadership's focus on maximizing realistic active sonar ASW training. No specific cause to over-mitigating has been determined; however, Navy is taking a pro-active role in improved training on mitigation procedures

Additionally, there were 12 reported instances of Navy ships proactively maneuvering to avoid marine mammals or sea turtles or to avoid crossing paths with marine animals.

In support of the 11 MTEs during the reporting period, the Navy conducted over 9,018 hours of Marine Species Awareness Training for 6,735 Navy personnel prior to the beginning of these exercises. While at sea, when accounting for the entire bridge watch team, the Navy spent over 112,192 hours of surface and aerial visual observation toward the detection of marine mammals and sea turtles. Additionally, over 1,626 hours were spent documenting and reporting marine animal sightings and mitigation events.

2.3 Utility of MTE Data

Sighting Per Unit Of Effort– The Navy evaluated marine mammal sighting data across all MTEs from three range complexes (Atlantic Fleet Active Sonar Training [AFAST], HRC, and Southern California Range Complex [SOCAL]) to determine if meaningful conclusions could be derived that contribute to addressing the general goals of the monitoring and reporting requirements. These goals, as outlined, in the LOA are:

- Increased probability of detecting animals
- Increased understanding of how many animals are exposed to acoustic stressors and the associated effects
- Increased understanding of acoustic stressor impacts to stocks and populations
- Increased knowledge of species
- Mitigation effectiveness
- Compliance with LOA and BO ITS

The approach used was to compute sightings per unit effort and determine if the results could potentially address any of these issues. The data was drawn from the MTEs conducted from January 2009 through August 2012, and only from ships with hull-mounted sonars, and presented in Table 2.3-1.

Table 2.3-1: Sightings per Unit Effort from Navy Major Training Events at Three Range Complexes from 2009 to 2012

Sonar Active/Passive	Percent of Time Active/Passive During MTE	# of Sightings	Percent of Sightings
January 2009 – August 2012			
Active	9.1%	500	29.3%
Passive	90.9%	1207	70.7%

Note: MTE = major training event

Since the actual hours of active sonar use is classified, the following data is presented in a format to ensure protection of the information and still provide the reader with meaningful results. The data showed animals are sighted less than 2 percent of the time during MTEs, less than 1 percent while sonar was passive and less than 5 percent while sonar was active.

This data is consistent with the number of mitigation actions as reported in Table 2.1-2; however, as presented in this analysis or other potential analyses that could be completed with this data set, it does not support any of the six goals stated above. Therefore, unless NMFS develops a study plan for how the data will be used, Navy recommends that in future LOAs and BOs this reporting requirement either be deleted or significantly revised.

3 COMPLIANCE MONITORING SUMMARY

3.1 OVERVIEW (2009 TO 2012)

From 2009 to 2012 COMPACFLT maintained compliance with the annual metrics outlined in the HRC monitoring plan (Department of the Navy 2008) and as amended in each annual LOA renewal request (Department of the Navy 2009a, 2010a, 2011a, 2012a).

It was, however, through this strict adherence to legally binding metrics that the Pacific Fleet began to note that while the annual metrics committed to were rigid (e.g., 120 hours of visual survey or 15 tags deployed), occurrence of training events, monitoring opportunities during those training events and acceptable survey weather were not consistent. For example, although the Navy complied with the LOA and monitoring plans, monitoring was occasionally conducted in poor weather or training conditions in order to meet annual commitments. Pacific Fleet recognized that there was potential, through committing to rigid metrics, to restrict the flexibility of the Navy to modify methods that might provide more robust and relevant monitoring data. Subsequent discussions with NMFS and other stakeholders ultimately lead to revisions outlined in the Strategic Plan (see Sections 1.1 and 6.2) that will allow for more flexibility.

Table 3.1-1: Monitoring Plan Metrics Accomplished Annually

	Monitoring Year			
Study Type	**2009**	**2010**	**2011**	**2012**
Visual surveys *(Study 1–5)*	–104 hours aerial during ASW and during 3 explosives events –40+ hours vessel during ASW and during two explosives events [Committed to: 120–160 hours ASW and five explosive events]	163.8 hours of aerial and vessel surveys [Committed to: 120–160 hours]	299.8 hours of aerial and vessel surveys [Committed to: 120–160 hours]	>232 hours of aerial and vessel surveys [Committed to: 120–160 hours]
Marine Mammal Observers *(Study 1–4)*	80 hours during ASW and 40 hours during explosive events [Committed to: same as accomplished]	239.3 hours during two ASW events and six explosive events [Committed to: 80 hours/three ASW, six explosives events]	Three ASW events and four explosive events. [Committed to: Two ASW and six explosive events]	Two ASW events and 10 explosive events [Committed to: Two ASW and six explosive]
Tagging *(Study 1–3)*	Tags ordered for PIFSC deployment [Committed to: same as accomplished]	Instrumented 11 Hawaiian monk seals [Committed to: 15 tagged]	–10 Hawaiian monk seals tagged; –Five attempted tag deployments on cetaceans, 4 successful -Continuing analyses of tag data from FY 2010 monitoring [Committed to: Goal of 15 animals]	15 attempted tag deployments on cetaceans, 14 successful [Committed to: Goal of 15 animals]
Passive Acoustic Monitoring *(Study 1–4)*	–Obtained use of four HARPs to be deployed in 2010 –Gathered and analyzed data from PMRF instrumented hydrophone range 2 days per month [Committed to: Obtain use of four autonomous recording devices]	–Deployed four EARs –Funded baseline analysis of archived PIFSC acoustic data –Gathered and analyzed data from PMRF instrumented hydrophone range 2 days per month –Prep for early award for analysis of archived EAR data [Committed to: same as accomplished]	–Deployed four EARs –Analyzed archived data from two EARS –Gathered and analyzed data from PMRF instrumented hydrophone range in conjunction with SCC + 2 days/month [Committed to: same as accomplished]	–Deployed four EARS and 18 sonobuoys –Analyzed data from eight historical EAR deployments –Gathered and analyzed data from PMRF instrumented hydrophone range in conjunction w SCC + 2 days/month [Committed to: exceeded by accomplishments]

Notes: (1) "Committed to" as used above is the 5-year commitment divided by the duration of the 5-year LOA is used as an index of progress; (2) ASW = Anti-submarine Warfare, EAR = Ecological Acoustic Recorder, FY = Fiscal Year, HARP = High-frequency Acoustic Recording Package, PIFSC = Pacific Islands Fisheries Science Center, PMRF = Pacific Missile Range Facility, SCC = Submarine Commanders Course

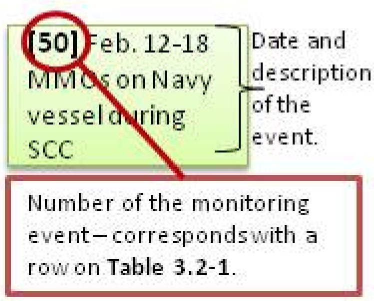
3.2 Chronological Timeline of HRC Monitoring

The central focus of this report is the 5-year monitoring period commencing in August 2008, but it is useful and important to consider monitoring activities prior to the official start of Tactical Training Theater Assessment and Planning (TAP), Phase 1 marine species monitoring. Taking into account the monitoring activities before August 2008 provides the context in which the current monitoring program was developed. Prior monitoring serves as baseline for measuring the progress made since the TAP, Phase 1 monitoring started. A timeline that is a graphic representation for understanding the progression of monitoring events is provided in Figure 3.2-1. Table 3.2-1 supports the timeline with text about the monitoring events; there is a row on the table for every green box on the timeline. See Box 1 for a key to reading the timeline.

At the time of writing this report, all 5 years of monitoring for TAP, Phase 1 have not been completed. The visual timeline (Figure 3.2-1) and Table 3.2-1 contain monitoring efforts that are completed, efforts that are ongoing, and efforts that are planned for the fifth monitoring year. Ongoing and planned efforts have not been completed, so their green boxes are outlined in dashed lines on the visual timeline and an explanation is provided in the far right column of Table 3.2-1.

Box 1. Key to the Visual Monitoring Timeline

- Time proceeds from left to right. The calendar years are labeled at the top of the page with the first and last months of the year labeled in the blue box.
- The black horizontal lines are timelines for four types of monitoring activities: aerial visual surveys (top line), vessel or shore visual surveys (second line from the top), tagging (third line from the top), and acoustic surveys (bottom line). The small, black vertical lines regularly spaced along the black horizontal timelines correspond with the end of one calendar year and the beginning of the next calendar year.
- On pages two and three of the visual timeline, the gray shaded areas signify the "monitoring year" — a 12-month period for which the monitoring activities encompassed in that period are reported. For HRC, SOCAL, and AFAST, that period was arbitrarily set to be from 1 August in one year to 31 July in the following year. The monitoring years are labeled by yellow boxes and black arrows at the bottom of the page. The first monitoring year for TAP, Phase 1 started in August 2008.
- Green boxes signify individual monitoring efforts. There is a row in Table 3.2-1 for every green box on the visual timeline. The figure to the left explains how to interpret the text and numbers in the green boxes. Green boxes are placed relative to the horizontal black lines at the general span of time during the year when the event took place. The amount of text dictated the size of boxes, so the actual span of time covered by monitoring activities is not accurately represented. Efforts may overlap in time, so green boxes are placed below and above the black horizontal timelines they relate to. In some cases, there are enough efforts overlapping that they are "stacked" above or below the line. As discussed in Section 3.2, dashed lines around a green box indicate that the monitoring effort is ongoing or planned at the time of writing.



- Red vertical lines connect efforts that were planned to be interactive while the monitoring was occurring or planned to be complementary in their results.
- Purple circles with red exclamation marks and black arrows highlight significant monitoring events. The arrows direct your attention to the monitoring effort during which the significant event took place.
- Blue circles provide information for interpreting the relationship between monitoring efforts.

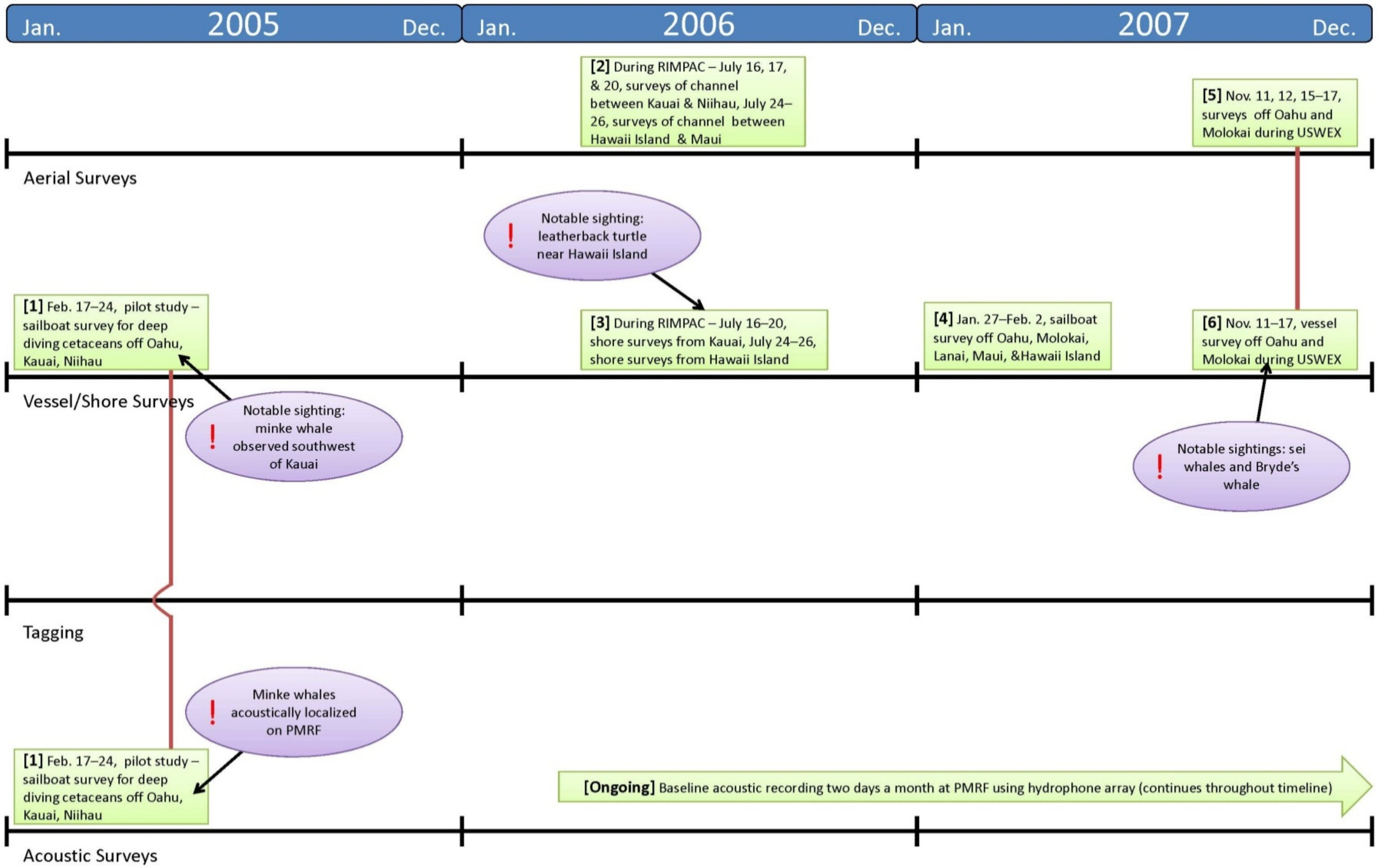


Figure 3.2-1: Visual Timeline

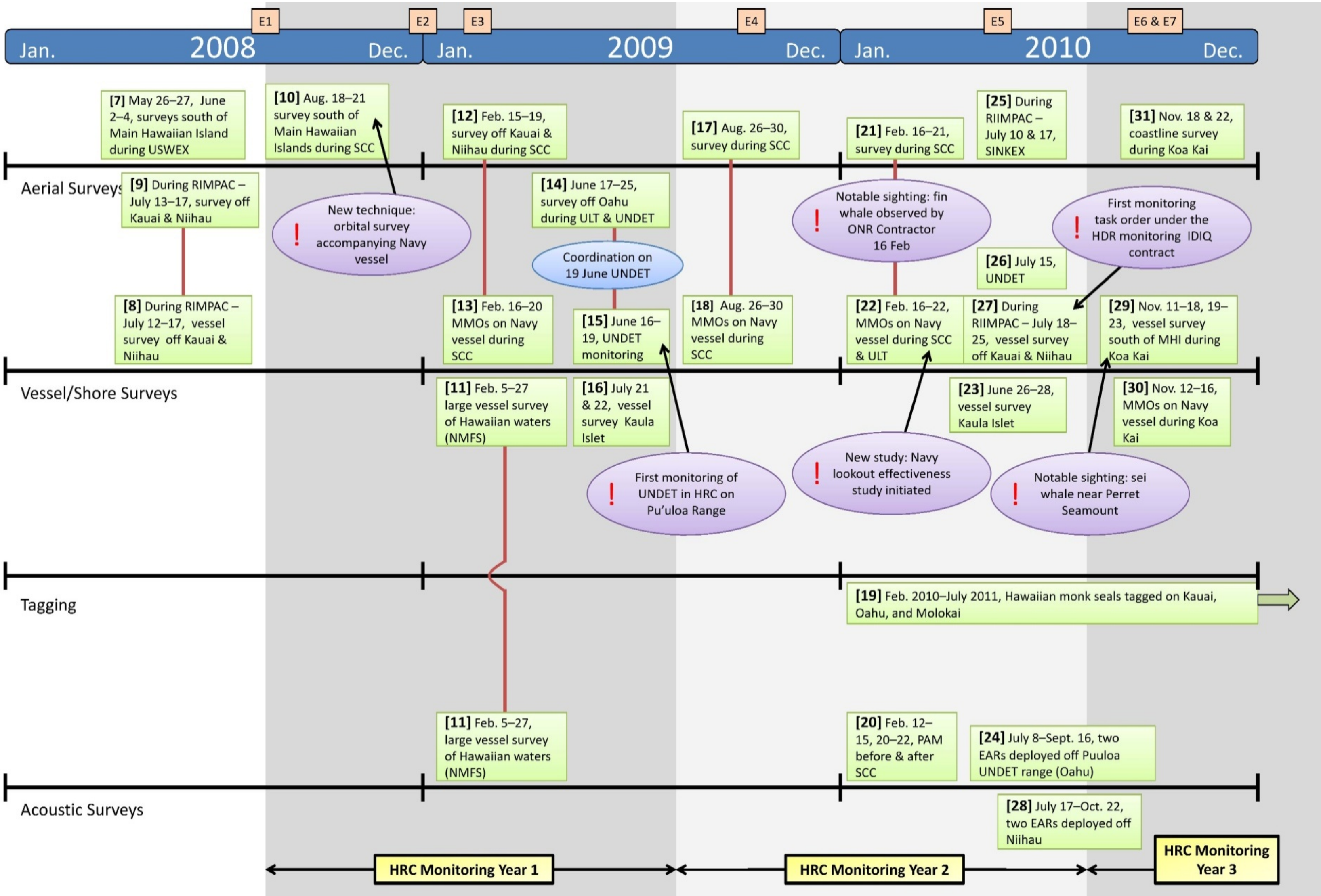


Figure 3.2–1: Visual Timeline (continued)

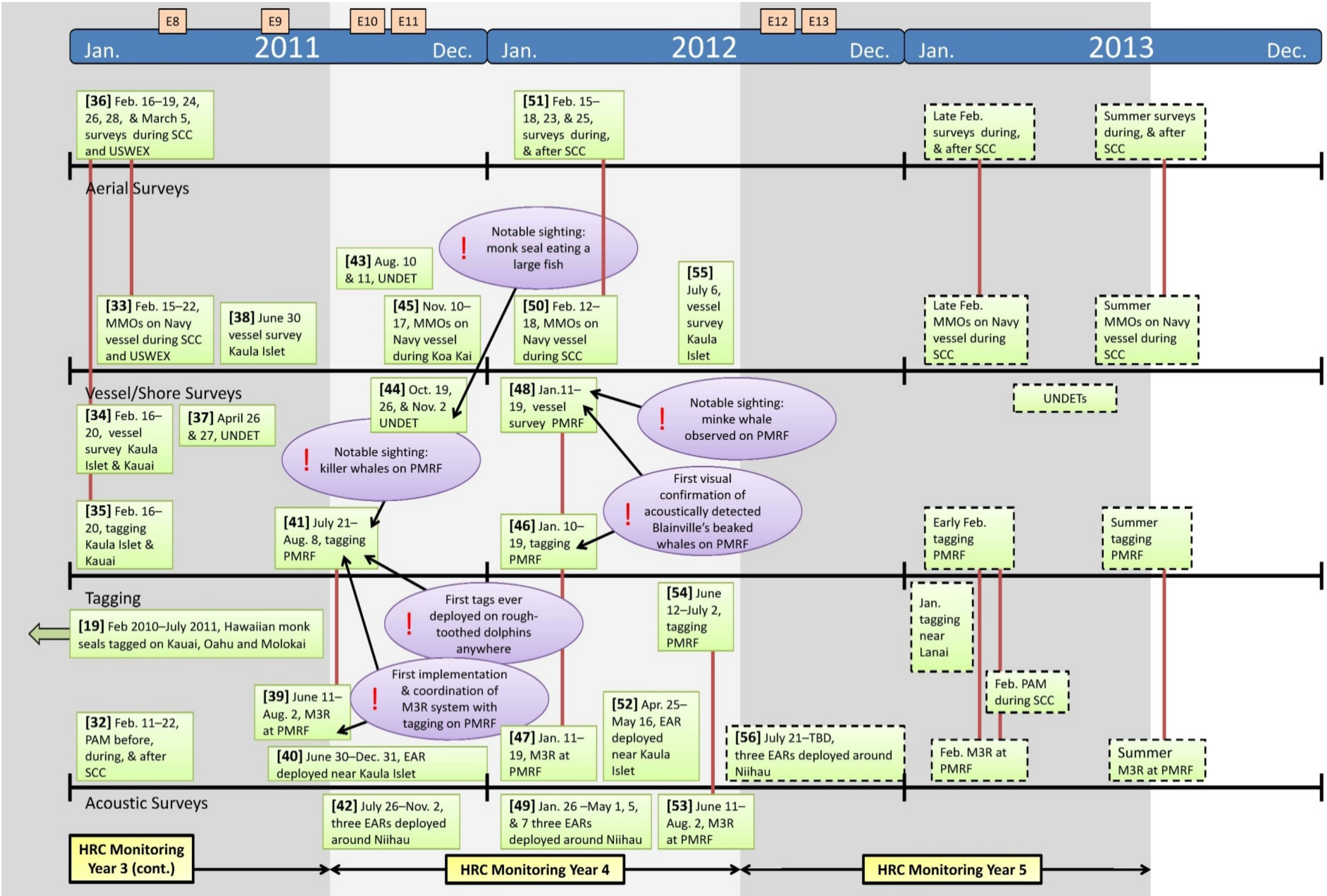


Figure 3.2–1: Visual Timeline (continued)

Table 3.2-1: Description of Monitoring Efforts and Key Events Related to Monitoring Rows Numbers Correspond to Green Monitoring Boxes and Orange Event Boxes in Figure 3.2-1

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
1	Vessel visual and passive acoustic survey 17–24 February 2005	Oahu, Kauai, Niihau	Pilot Study • Conduct a survey for cetaceans in deep waters (100–2,500 fathoms) • Test passive acoustic methods in order to maximize encounter rates with cetaceans	• Distance sampling • Two towed hydrophone arrays • Acoustic localization using ISHMAEL software • DiFAR sonobuoys • Photo-identification • Biopsy (unsuccessful)	• bottlenose dolphin • humpback whale • minke whale • short-finned pilot whale • sperm whale (not observed, detected acoustically only) • spinner dolphin • unidentified beaked whale (possibly M. densirostris)	• 745 km of trackline covered, 397 km of acoustic effort, 251 km visual effort • 13 sightings • Humpback whale/pilot whale multi-species group observed • Minke whales detected visually and acoustically • Minke whale acoustic detections on PMRF • Minke whales and humpback whales localized using acoustic systems • Sighting conditions poor north of Kauai (near PMRF) • Sailboat is quiet, but wind affects trackline • Deploying DiFAR sonobuoys is serviceable, software for real-time analysis problematic
2	Aerial surveys 16, 17, 20, 24–26 July 2006	Kauai, Niihau, Maui, Hawaii Island	• Monitoring during RIMPAC swept-channel training events • Observe marine species in the area	• Aerial visual sampling • Line-transect grid survey	• bottlenose dolphin • Cuvier's beaked whale • false killer whale • spotted dolphin • unidentified dolphin sp. • unidentified beaked whale sp.	• 1,296 km of trackline covered, 556 km near Kauai, 740 near Island of Hawaii • 13 sightings • Sighting conditions poor on 5 of the 6 days, mean BSS >4 for 5 days
3	Shore-based survey	Kauai, Hawaii	• Monitoring during	• Scan sampling from	• bottlenose dolphin	• 13 sightings

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
	16–26 July 2006	Island	RIMPAC swept-channel training events • Observe marine species near shore • Observe marine species behavior before, during, and after swept-channel training events	shore	• spinner dolphin • green turtle • leatherback turtle	• Leatherback turtle sighted 300 m from shore on Island of Hawaii
4	Vessel visual survey 27 January–2 February 2007	Oahu, Molokai Lanai, Maui, Hawaii Island	• Monitoring during Navy training event • Report surface behavior of marine mammals observed • Survey coastal waters along the east side of the Island of Hawaii	• Distance sampling • Focal animal sampling • Photo-identification	• bottlenose dolphin • false killer whale • humpback whale • pygmy killer whale • short-finned pilot whale • spinner dolphin • unidentified beaked whale sp. • unidentified dolphin sp. • unidentified large whale (probably sperm whale) • unidentified medium whale	• 530 km of trackline covered during observation, 444 km during visual survey, 86 during focal effort • 97 sightings, 87.6% of sightings were humpback whales • 75 sightings were on Penguin Banks or in Maui Basin • Pygmy killer whale/pilot whale multi-species group observed feeding (along with birds and sharks) • Video used successfully during focal animal sampling
5	Aerial surveys 11, 12, 15–17 November 2007	Between Oahu and Molokai, shorelines of Oahu & Molokai	• Monitoring during USWEX training events • Observe marine species in the	• Aerial visual sampling o Line-transect grid survey o Shoreline survey	• bottlenose dolphin • short-finned pilot whale • spinner dolphin	• 3,150 km of trackline • 26 sightings • Helicopter used for shoreline surveys • Two monk seal sightings, one

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			area • Report surface behavior of marine mammals observed • Identify stranded cetaceans on shorelines		• Stenella sp. • unidentified dolphin sp. • unidentified mysticetes • Hawaiian monk seal • unidentified turtle sp.	individual in water, two individuals on beach • More than 60% of survey time was spent in BSS ≥4
6	Vessel visual survey 11–17 November 2007	Between Oahu and Molokai	• Observe marine species behavior before, during, and after Navy training event • Report surface behavior of marine mammals observed • Remain within view of opportunistically encountered Navy vessels	• Distance sampling (big eye scopes) o Line-transect grid survey • Focal animal sampling • Photo-identification • XBT	• Bryde's whale • humpback whale • Risso's dolphin • sei whale • spinner dolphin • unidentified small delphinid • unidentified small whale	• 911 km of trackline covered during observation, 817 km during visual survey, 105 during focal effort • Eight sightings • First verified sighting of Bryde's whale in Hawaiian Islands; focal follow obtained while Navy vessel was on horizon • Two sightings of sei whales off Oahu, including a group of three subadults • Using Big Eye scopes on research vessel was effective way to observe species • Survey boat was able to remain within sight of Navy vessels • 44% of survey time was spent in BSS ≥5
7	Aerial surveys 26, 27 May & 2–4 June 2008	South of main Hawaiian Islands, shorelines of Hawaii Island, Kahoolawe,	• Monitoring during USWEX training events • Observe marine species in the area • Report surface	• Aerial visual sampling o Line-transect grid survey o Shoreline survey	• spinner dolphin • striped dolphin • unidentified dolphin sp. • unidentified turtle sp.	• 3,889 km of trackline • 15 sightings • Final 2 days visibility hampered by volcanic haze • Helicopter used for shoreline surveys

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
		Lanai	behavior and direction of travel of marine mammals observed • Identify stranded cetaceans on shorelines			• 68% of survey time was spent in BSS ≥4 • Turtles observed only during the shoreline survey (seven sightings)
8	Vessel visual survey 12–17 July 2008	Kauai, Niihau	• Observe marine species behavior during RIMPAC training event • Report surface behavior of marine mammals observed • Remain within view of opportunistically encountered Navy vessels	• Distance sampling (big eye scopes) o Line-transect grid survey • Focal animal sampling o Scan sampling o One-zero sampling • Photo-identification • XBT • Coordination between vessel and aerial survey platform (row 9)	• bottlenose dolphin • rough-toothed dolphin • spinner dolphin	• 474 nm of trackline covered during observation, 373 nm during visual survey, 34 nm during focal effort, 68 nm during transit from Oahu • Nine sightings • Plane was able to communicate localized survey conditions to vessel • Three rough toothed dolphin groups (~22 individuals) observed by focal follow while Navy ships in sight. No unusual surface behaviors were observed. Feeding was observed during two of the focal samples • All nine dolphin groups approached the vessel; eight of the nine groups engaged in bowriding • Rough-toothed dolphins groups observed in 900–1800 m depth near steep underwater canyon • 66% of survey time was spent in BSS ≥4
9	Aerial surveys 13–17 July 2008	Kauai, Niihau, area south of Kauai, transit between Oahu and Kauai	• Observe marine species in the area during RIMPAC training event • Report surface	• Aerial visual sampling using distance sampling methodology o Line-transect grid survey	• bottlenose dolphin • Blainville's beaked whale • Cuvier's beaked whale	• 24.6 hours of observation • 24 sightings • Group of six Blainville's beaked whale observed south of PMRF • Cuvier's beaked whale observed in

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			behavior and direction of travel of marine mammals observed • Identify stranded cetaceans on shorelines	o Shoreline survey	• rough-toothed dolphin • short-finned pilot whale • spinner dolphin • striped dolphin • unidentified dolphin sp. • Hawaiian monk seal • unidentified turtle sp.	the channel between Oahu and Kauai • Six sightings of Hawaiian monk seals hauled out on Niihau • ~50% of survey time was spent in BSS ≥5 • Turtles observed only near the shore of Kauai (three sightings)
E1	**August 2008 – Commence first monitoring year for TAP, Phase 1 Letter of Authorization**					
10	Aerial surveys 18–21 August 2008	Kauai, Niihau, area south of Kauai, transit between Oahu and Kauai	• Monitoring during SCC • Observe marine species in the area to determine distribution and abundance • Report surface behavior and direction of travel of marine mammals observed • Obtain locations of animals so that received MFAS sound levels could be calculated • Assess the	• Aerial visual sampling using distance sampling methodology o Orbital survey accompanying Navy vessel o Shoreline survey • Focal group sampling o Scan sampling o One-zero sampling • Radio communication with Marine Mammal Observers (MMOs) on Navy vessel	• Spinner dolphin • unidentified turtle sp. • whale shark	• 28.5 hours of observation (19.0 hours accompanying a Navy vessel, 9.5 hours of opportunistic observation) • 21 sightings, all near shore • Plane successfully accompanied Navy vessel • Whale shark successfully tracked at >30' below water surface • Navy vessel communicated acoustic detections of sperm whales and delphinids to aerial platform • Communications between MMOs on Navy vessel and aerial platform were difficult • No sightings near Navy vessel • Turtles observed only near shore of Kauai and Oahu (18 sightings) • 80% of survey time with the Navy vessel was spent in BSS ≥5

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			feasibility and capability of monitoring marine mammals near Navy vessel • Determine if marine mammals can be tracked below the surface by plane			• 38% of opportunistic survey time was spent in BSS ≥5
E2	**HRC Monitoring plan finalized in December 2008 for implementation in January 2009**					
11	Large vessel visual and passive acoustic survey 5–26 February 2009	MHI EEZ	• Collect distributional and presence data needed to develop updated abundance estimates for the same species collected on the summer/fall 2002 HICEAS • Additional survey lines added to assess the region east and north of Kauai	• Visual and acoustic line-transect survey • Sonobuoy deployments	• bottlenose dolphin • Cuvier's beaked whale • Bryde's whale • false killer whale • humpback whale • melon-headed whale • minke whale • pygmy killer whale • rough-toothed dolphin • short-finned pilot whale • spotted dolphin • striped dolphin • Balaenoptera sp. • sei whale/Bryde's whale • unidentified dolphin	• Actual field survey was not supported by COMPACFLT. Funds to partially support the analysis of the data was supplied by COMPACFLT. • 117 sightings, 62 acoustic detections • Minke whales were heard almost constantly

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
					• unidentified large whale • unidentified medium delphinid • unidentified small delphinid	
12	Aerial surveys 15–19 February 2009	PMRF, Kauai, Niihau, transit between Oahu and Kauai, shorelines of Kauai & Niihau,	• Monitoring during SCC • Observe marine species in the area to determine distribution and abundance • Report surface behavior and direction of travel of marine mammals with respect to Navy vessel being tracked • Identify stranded cetaceans on shorelines • Coordinate with MMOs on the Navy vessel (row 13), Navy aircraft on the range, and range control, to facilitate maximizing survey time and project safety	• Aerial visual sampling using distance sampling methodology o Orbital survey accompanying Navy vessel o Shoreline survey • Focal group sampling o Scan sampling	• humpback whale • unidentified dolphin sp. • unidentified mysticetes • unidentified turtle sp.	• 27.3 hours of observation (13.9 hours accompanying Navy vessel, 13.4 hours of opportunistic observation) • 63 sightings, primarily humpback whales near shore • Data collected electronically with hand-held devices (Palm Pilot and iPhone) • Eight humpbacks observed while accompanying Navy vessel, one focal follow recorded for approximately 30 minutes. • One humpback group of three whales was observed before and during the approach of two Navy vessels. Scientists noted increased dive time and reduced number of blows at the surface as vessels passed within 0.5 to 2 km. Sonar was not in use. • 96% of survey time with the Navy vessel was spent in BSS ≥5 • Scope of work for contract specified that results were to be compiled with previous and subsequent data to interpret over time and increase the sample size

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
13	MMOs on Navy vessel 16–20 February 2009	PMRF, Kauai, Niihau, transit between Oahu and Kauai	• Coordinate transit to PMRF to allow the Navy vessel and survey aircraft to test communications and familiarize ship to plane transect profiles • Collect data on marine mammals observed during training • Coordinate with the contracted aerial survey team (row 12), Navy aircraft on the range, and range control to maximize survey time and project safety • Familiarize MMOs with at-sea Navy operations and gather information to facilitate future MMO opportunities	• Scan sampling • Photo-identification of species	• humpback whale • unidentified turtle sp.	• 727.5 km of trackline covered during observation • Nine sightings, eight were humpback whales • Vessel was a destroyer • Communications with the survey aircraft proved successful. Sightings made by the MMOs were successfully transmitted to the survey aircraft, which was then able to locate the animals. • Communication between the survey aircraft, range control, and other aircraft was successful, maintaining safety of all participants.
E3	**19–20 February 2009 – OPNAV N45 Marine Mammal Monitoring Workshop, R. David Thomas Executive Conference Center, Duke University, Durham, North Carolina**					
14	Small vessel surveys 17–19 June	Puuloa UNDET range near	• Monitor for presence of marine mammals	• Scan sampling from vessel (Navy	• spinner dolphin • green turtle	• NMFS vessel and Navy observers monitored UNDET events. NMFS monitored area the day before the

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
	2009	Pearl Harbor (Oahu)	and turtles during UNDET events on the Puuloa UNDET range	observers) • Vessel transect grid survey (NMFS vessel) • Coordination between two vessel observing UNDET and aerial survey platform on June 19 (row 15) • Focal group sampling (by NMFS vessel) • Photo-identification (by NMFS)		UNDET events. • Three sightings on 18 June: two turtles and one group of spinner dolphins • Six explosive events monitored • UNDET events were delayed to allow turtles to leave area • All monitoring during UNDETs occurred in Beaufort 4 or 5 • NMFS made recordings of the explosions
15	Aerial surveys 17–25 June 2009	South of Oahu, and Puuloa UNDET range near Pearl Harbor	• Monitoring during ULT and UNDET events on the Puuloa UNDET range • Observe marine species in the area to determine distribution and abundance • Report surface behavior and direction of travel of marine mammals with respect to Navy vessel being tracked	• Aerial visual sampling using distance sampling methodology o Orbital survey accompanying Navy vessel o Line-transect grid survey • Focal group sampling o Scan sampling • Coordination between two vessel observing UNDET and aerial survey platform on June 19 (row 14)	• Risso's dolphin • spotted dolphin • striped dolphin • unidentified dolphin sp. • unidentified turtle sp.	• 44.96 hours of observation (12.82 hours searching for or accompanying Navy vessel, 25.65 hours of line transect survey, 6.5 hours monitoring UNDET events) • 42 sightings, primarily turtles during UNDET monitoring (38 sightings) • Helicopter was used for UNDET monitoring in 5.75 km x 5.75 km area. Aerial monitoring over Puuloa UNDET range determined to be non-ideal because it is located in the final flight approach area for Honolulu International Airport. • Helicopter observed one UNDET event • 83% of survey time was spent in BSS ≥5
16	Vessel visual survey 21–22 July 2009	South of Niihau, Kaula Island, channel between	• Observe marine species in the area • Assist with sea bird counts on	• Scan sampling	• bottlenose dolphin • spinner dolphin • spotted dolphin	• Five sightings • Monk seals observed hauled out on ledges on Kaula Island. • The spinner and bottlenose dolphins

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
		Niihau and Kaula Island	Kaula Island		• Hawaiian monk seal •	were observed within 0.5 km of Kaula Island.
17	Aerial surveys 26–30 August 2009	PMRF, Kauai, Niihau, transit between Oahu and Kauai, shorelines of Kauai and Niihau,	• Monitoring before, during, and after SCC • Report surface behavior of marine mammals with respect to Navy vessel being tracked • Identify stranded cetaceans on shorelines • Coordinate with MMOs on the Navy vessel (row 18)	• Aerial visual sampling using distance sampling methodology o Line-transect grid survey o Orbital survey accompanying Navy vessel o Shoreline survey • Focal group sampling o Scan sampling	• false killer whale • pygmy killer whale • rough-toothed dolphin • spinner dolphin • spotted dolphin • unidentified dolphin sp. • Hawaiian monk seal • unidentified turtle sp.	• 31.4 hours of observation (13.7 hours accompanying Navy vessel, 17.7 hours of systematic observation) • 7,048 km of trackline, 3,019 km accompanying Navy vessel, 4,029 km of systematic observation • 19 sightings, all eight monk seal sightings were on western beaches of Niihau, one turtle seen near shore of Kauai • No sightings while accompanying Navy vessel • Eight sightings before SCC, six sightings after SCC, six sightings during transits during SCC • Line-transect grid survey flown the day before and after SCC • Rough-toothed dolphin/pygmy killer whale multi-species group observed • 75% of survey time was spent in BSS ≥5
18	MMOs on Navy vessel 26–30 August 2009	PMRF, Kauai, Niihau, transit between Oahu and Kauai	• Coordinate transit to PMRF to allow the Navy vessel and survey aircraft to test communications and familiarize ship to plane transect profiles	• Scan sampling • Photo-identification of species	• unidentified dolphin sp. • unidentified turtle sp.	• 616.2 km of trackline covered during observation • No sightings while on effort during the embark • Off effort sightings included two turtles observed as leaving Pearl Harbor, one dolphin observed in Pearl Harbor when returning • Vessel was a cruiser

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			• Collect data on marine mammals observed during operations • Coordinate with the contracted aerial survey team (row 17), Navy aircraft on the range, and range control to facilitate maximizing survey time and project safety • Familiarize MMOs with at-sea Navy operations and gather information to facilitate future MMO opportunities			
E4	**October 2009 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
19	Cell phone tags on Hawaiian monk seals, February 2010–December 2010	MHI	• Monitor monk seal habitat use and behavior: determine home range sizes, foraging areas, and identify potential foraging hot spots of seals in the MHI. • Identify potential changes in monk seal behavior in	• Tagging	• Hawaiian monk seal	• Between 10 February and 29 June 2010 11 tags deployed: three tags deployed on Oahu, four tags deployed on Kauai, four tags deployed on Molokai • Four tags came off animals prematurely • Between 21 January and 15 July 2011) 10 tags deployed: two tags deployed on Oahu, three tags deployed on Kauai, five tags deployed on Molokai

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			relation to Navy activities in the MHI			• The data from four tags were not able to be downloaded • Four of the 11 tagged seals for which data could be retrieved crossed the south end of the shallow water range at PMRF between Kauai and Niihau. • Results indicate: o In a single day, seals spent, on average, 4.4 hours at the water surface, 11.6 hours diving, and 7.0 hours hauled-out on land. o Average foraging trips were 29.7 km in 19 hours (0.79 days) o With the exception of one trip, none of the seals traveled more than 300 km per trip and most traveled < 50 km. o Two seals made at least one long pelagic foraging trip during the deployment period. An adult male tagged on Oahu, traveled over 3,000 km on one trip which lasted 36 days. A sub-adult female tagged on Kauai, traveled 300 km on one trip that lasted almost 4 days. o Mean dive depth was 27.03 m with a maximum of 529 m and a median depth of 14.4 m o Most of the seals remained within the 600 m depth contour o Average dive duration was 5.01minutes with a median of 5.07 minutes and 28% of the time spent between dives being spent at the surface o There was high variability in the space utilized by individuals o 54% of the seals made regular trips between two or more of the islands,

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						while the remainder showed fidelity to one island o Fixed kernel density home range and core area estimates were calculated for all 11 seals. Most seals had core areas on one island regardless of their inter- island travels; however, two animals that spent considerable time on multiple islands had segmented core areas that spanned multiple islands. o Core area sizes were similar between seals, while home range sizes were more variable
20	PAM 12–15 and 20–22 February 2010	PMRF	• Determine if there are beaked whales and minke whales present on PMRF before and after SCC	• Automated passive acoustic detection and classification algorithms accompanied by manual verification	• minke whale • unidentified beaked whale	• Recordings made before and after SCC using PMRF hydrophone array • 80.8 hours of recording before the SCC, 45.3 hours of recording after SCC • Beaked whale species are expected to be Blainville's or Cuvier's beaked whale • Beaked whales are detected and diving events are counted with certainty before and after SCC. • There appeared to be a similar number of foraging dives counted immediately before and after the SCC. Fewer beaked whale echolocation clicks occurred in the 45 hours after the SCC than before the SCC. The reason for the same number of dives but fewer clicks is undetermined. • The rate of minke whale boings was variable before and after SCC, but the overall average number of boings is similar before and after SCC.

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
21	Aerial surveys 16–21 February 2010	PMRF, Kauai, Niihau, transit between Oahu and Kauai, shorelines of Kauai, Niihau, and Kaula Island	• Monitoring before, during, and after SCC • Report surface behavior of marine mammals with respect to Navy vessel being tracked • Identify stranded cetaceans on shorelines • Coordinate with MMOs on the Navy vessel (row 22)	• Aerial visual sampling using distance sampling methodology o Line-transect grid survey o Orbital survey accompanying Navy vessel o Shoreline survey • Focal group sampling o Scan sampling	• humpback whale • false killer whale • short-finned pilot whale • bottlenose dolphin • rough-toothed dolphin • spinner dolphin • spotted dolphin • striped dolphin • unidentified blackfish • unidentified dolphin sp. • unidentified whale • unidentified cetacean • unidentified turtle sp.	• 33 hours of observation (7.8 hours accompanying Navy vessel, 25.2 hours of systematic observation) • 6,023 km of trackline • 304 sightings, 265 were humpback whales • One pod of two humpback whales observed while accompanying Navy vessel. Focal follow footage was obtained. • All 12 turtles sightings occurred near shore • 63% of survey time was spent in BSS ≥5
22	MMOs on Navy vessel 16–22 February 2010	PMRF, Kauai, Niihau, transit between Oahu and Kauai	• Collect data to assess the effectiveness of the Navy LO team • Collect data on marine mammals observed during operations • Obtain data to characterize the possible exposure of	• Distance sampling • Photo-identification of species	• humpback whale • sperm whale • striped dolphin • rough-toothed dolphin • unidentified whale	• 24 sightings during embark • Humpback whales and striped dolphins seen on PMRF range • Vessel was a frigate • Because rate of marine mammal encounter is relatively low, data for LOE Study will need to be assessed over many embarks • 12 (50%) of the sightings by the MMOs were potential trials for the effectiveness study

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			marine species to MFAS. • Achieve close coordination between the contracted aerial survey team (row 21), Navy aircraft on the range, range control, and the MMO team to facilitate maximizing survey time and project safety.			• Sea state was high on PMRF for 2 days, resulting in no sightings on those days
E5	**17–18 June 2010 – Marine Species Monitoring Contract Kickoff and Coordination Meeting, Navy and HDR|EOC, Marriott Hotel, San Diego, California**					
23	Vessel visual survey 26–28 June 2010	Niihau, Kaula Island, channel between Niihau and Kaula Island	• Monitor area near PMRF prior to RIMPAC • Observe marine species in the area • Assist with sea bird counts on Kaula Island	• Line-transect survey • Distance sampling • Photo-identification	• false killer whale • bottlenose dolphin • rough-toothed dolphin • spinner dolphin • unidentified cetacean • unidentified dolphin sp.	• Seven sightings • False killer whales did not have a match in the MHI insular false killer whale catalog. The group of three individuals was comprised of an adult male, an adult female, and a young calf. • The spinner dolphins were observed within 0.5 km of Kaula Island, as with previous Kaula survey (row 16).
24	PAM devices 8 July–16 September 2010	Puuloa UNDET range	• Monitor sound budget of UNDET range during RIMPAC • Determine basic pattern of presence/absence of marine mammals on	• Moored PAM devices	• TBD	• Two EARs deployed on Puuloa UNDET range • Analysis commencing late in FY 2013

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			UNDET range			
25	Aerial monitoring 10 and 17 August 2010	PMRF	• Monitor SINKEX events during RIMPAC	• Scan sampling	• none	• Monitoring occurred from helicopters • Distances required for safe observation of SINKEX is too distant to accommodate reasonable monitoring evaluation.
26	Small vessel survey 15 July 2010	Puuloa UNDET range near Pearl Harbor	• Monitor for presence of marine mammals and turtles during UNDET events on the Puuloa UNDET range	• Scan sampling from vessel • Photo-identification	• green turtle	• Three hours of observation • Two sightings, observed while transiting to and from UNDET range • Four explosive events monitored
27	Small vessel survey 18–25 July 2010	South of Kauai and Niihau	• Monitoring area near PMRF during RIMPAC • Observe marine species in the area • Assess the diversity, distribution, and behavior of target species	• Line-transect survey • Distance sampling • Focal group sampling o Scan sampling • Photo-identification	• rough-toothed dolphin • short-finned pilot whale • spinner dolphin • unidentified cetacean • Hawaiian monk seal	• 66 hours of observation • 726.99 km of trackline • Nine sightings • First monitoring task under the 5-year monitoring contract • Monk seal observed swimming in middle of channel between Kauai and Niihau • Spinner dolphin/pilot whale multi-species group observed • Two focal group samples taken on pilot whales • Sea state was low in the morning and progressed to high by midday. Most days were forced to end by mid afternoon. • High sea states prevented surveying offshore on all days except one. • The small vessel was able to be flexible and adjust schedule and

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						survey pattern to environmental conditions.
28	PAM devices 17 July 2010–22 October 2011	Niihau	• Monitor for marine mammal presence near PMRF range	• Moored PAM devices • Biosonar was target of detection software applied to deep EAR • Beaked whales detected using three automated detection algorithms • TRITON used to analyze whistles on shallow EAR	• Risso's dolphin • short-finned pilot whale • sperm whale • unidentified beaked whale (probably Cuvier's or Blainville's) • unidentified small dolphin sp.	• Two EARs deployed near Niihau, one on the north side at 732 m depth, one on south side at 17 m depth • 10% duty cycle, sampling rate was 80 kHz • Recording scheduled for 6 months, both devices recorded for 3.2 months • Deep EAR results: • Beaked whales were the least detected cetaceans, pilot whales were the most detected • Sperm whales detected on all days except one • Beaked whales detected on 90% of the days • Other species detected every day • Majority of biosonar detection for all species occurred at night (low 77% for sperm whale, high 89% for beaked whale); this may be dependent on foraging and prey availability • Risso's dolphin identification is questionable • Shallow EAR results: • Dolphin whistles and clicks present on 32% of the days • Most of the whistle events occurred in the mornings between 0600 and 0900 • MFAS detected on 5 days
E6	**19 October 2010 – Navy Marine Species Monitoring Review Meeting, NMFS, Navy, HDR|EOC, Contractors, & Marine Scientists, Arlington, Virginia**					

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
E7	**20 October 2010 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
29	Medium vessel survey 11–18 and 19–23 November 2010	South of MHI	• Monitor general area where Koa Kai was taking place • Investigate the occurrence, distribution, and behavior of target species during Koa Kai • Locate false killer whales, pygmy killer whales, and short-finned pilot whales tagged by Cascadia Research Collective	• Line-transect survey • Distance sampling • Focal group sampling o Scan sampling • Photo-identification	• bottlenose dolphin • dwarf sperm whale • false killer whale • humpback whale • minke whale • pygmy killer whale • rough-toothed dolphin • sei whale • short-finned pilot whale • spotted dolphin • Mesoplodon sp. • unidentified large whale • unidentified small whale	• 95.3 hours of observation • 1,323.5 km of trackline • 26 sightings • Eight sightings of pilot whales • There was an aggregation of deep-diving and lesser-sighted species around the seamounts west of Hawaii Island • Focal follows conducted on bottlenose dolphins, a false killer whale, pilot whales, pygmy killer whales, rough-toothed dolphins, a sei whale, and spotted dolphins • Flexibility allowed the vessel to remain within the lee of islands which provided better sighting conditions • 17.24% of survey time was spent in BSS ≥4
30	MMOs on Navy vessel 12–16 November 2010	PMRF, Kauai, Niihau, transit between Oahu and Kauai	• Collect data to assess the effectiveness of the Navy LO team • Collect data on marine mammals observed during operations • Obtain data to characterize the possible exposure of marine species	• Distance sampling • Photo-identification of species	• spinner dolphin • spotted dolphin • unidentified Balaenopterid • green turtle • unidentified turtle sp.	• Eight sightings during embark, five of the sightings were turtles • Vessel was a cruiser • Three of the sightings by the MMOs were potential trials for the effectiveness study • 73% of survey time was spent in BSS ≥4

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			to MFAS			
31	Aerial surveys 18 and 22 November 2010	Shorelines of Molokai, Maui, Molokini, Kahoolawe, Lanai, and the west coast of Hawaii Island	• Assess the occurrence, distribution, and behavior of marine mammals and sea turtles using nearshore line transects after Koa Kai • Identify stranded cetaceans on shorelines	• Aerial visual sampling using distance sampling methodology o Shoreline survey • Photo-identification of species	• bottlenose dolphin • false killer whale • humpback whale • spinner dolphin • unidentified delphinid • unidentified turtle sp.	• 914.1 hours of observation • 2,322 km of trackline • 125 sightings, 101 were turtles • BSS ranged from 2 to 4 with a mean of 3
32	PAM 11–22 February 2011	PMRF	• Monitoring the acoustic environment on PMRF before, during, and after SCC. • Calculate sound pressure levels reaching whales localized on the range	• Automated passive acoustic detection and classification algorithms accompanied by manual verification • Estimating sound pressure levels using ray trace models and sonar equations • Use PMRF hydrophone array to validate sound pressure level estimations	• humpback whale • minke whale • short-finned pilot whale • sperm whale • unidentified beaked whale • unidentified large whale	• 65.6 hours of recording before, 113.6 during, 79 hours of recording after SCC • First time recording during SCC was allowed in the HRC • Used PMRF hydrophone array which had been recently upgraded • Variability in the average minke whale boing rate is high and shows low values during SCC. It is unclear if the depressed values are part of normal variation or a result of the exercise activity. Boing rate and variability were highest after the SCC. • Exposure levels were estimated for three separate 3 kHz MFAS transmissions for a minke whale, a humpback whale and a group of unidentified whales. • Results show the highest estimated exposure level of 164 dB SPL re 1 μPa was for the group of unidentified whales

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						• A minke whale was acoustically automatically detected, classified and localized. The minke was exposed to an estimated SPL of 139 to 145 dB re 1 μPa. • The minke whale did not seem to significantly change its swim behavior or vocal pattern. • A single, manually derived, acoustic localization for a humpback whale estimated it was exposed to a SPL of between 136 to 141 dB re 1 μPa. • Beaked whale clicks did not show a change in vocal periods associated with diving with respect to before during and after the SCC (and use of MFAS). • Additional modeling of estimated received levels for 16 sightings & re-sightings of humpback whales by the aerial survey team and MMOs on the Navy vessel • Minimum estimated received level was 136.2 dB re 1 μPa at 71 km from sonar • Maximum estimated received level was 183.6–196.9 dB re 1 μPa at 0.5–0.08 km from sonar (position of whale uncertain at time of ping) • Additional modeling of estimated received levels for beaked whale groups that were detected acoustically o Of the ten beaked whale dives analyzed, the estimated SPLs at one km depth span from 81 to 139 dB re 1 μPa. The mean estimated SPL is 115.4 dB re 1

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						µPa (9.5 dB SD) o The estimated SPLs if the animals were near the surface (10 m depth) span from 139 to 161 dB re 1 µPa. The mean estimated SPL is 149.8 dB re 1 µPa (5.7 dB SD). o Recordings from the range indicate that beaked whale dives continue to occur at PMRF while MFAS activity is occurring.
E8	**1–2 March 2011 – Scientific Advisory Group Meeting, HDR|EOC Offices, San Diego, California**					
33	MMOs on Navy vessel 12–16 November 2011	PMRF, Kauai, south of MHI	• Collect data to assess the effectiveness of the Navy LO team • Collect data on marine mammals observed during operations • Obtain data to characterize the possible exposure of marine species to MFAS • Achieve close coordination between the contracted aerial survey team (row 35), Navy aircraft on the range, range control, and the MMO team to facilitate maximizing survey time and	• Distance sampling • Photo-identification of species	• humpback whale • Risso's dolphin • short-finned pilot whale • spinner dolphin • striped dolphin • unidentified Balaenopterid • unidentified small cetacean • unidentified Stenella sp. • unidentified whale • green turtle	• 34 sightings during embark, 13 of the sightings were humpback whales • Vessel was a destroyer • 23 of the sightings by the MMOs were potential trials for the effectiveness study • Humpback whales observed in vicinity of boat during MFAS use • 66% of survey time was spent in BSS ≥4Highest sea states were encountered on PMRF and south of Molokai and Lanai

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			project safety			
34	Medium vessel survey 16–20 February 2011	Kauai, Kaula Island, Niihau	• Monitor area near PMRF during SCC • Observe marine species in the area • Support marine mammal tagging effort (row 35) • Coordinate tagging team (row 35) and aerial survey team (row 36) • Assist with sea bird counts on Kaula Island	• Line-transect survey • Distance sampling • Non-random, non-systematic survey • Photo-identification	• bottlenose dolphin • Hawaiian monk seal • humpback whale • short-finned pilot whale • spinner dolphin • rough-toothed dolphin • unidentified dolphin • unidentified large whale	• 508.72 km of trackline • 34.7 hours of observation • 19 sightings other than humpback whale or unidentified large whale, six sightings of rough toothed dolphin (more than expected) • On 16 February, 39 humpback whale sightings and seven unidentified large whale sightings in a single day • Large vessel with MMOs supporting tagging team in smaller boat was very successful • Non-random, non-systematic survey allowed great flexibility for the boat to remain in locations with better sighting conditions • Methodology required humpback whales to be ignored during non-random, non-systematic survey periods, otherwise they would swamp out other sightings • Humpback whale/pilot whale multi-species group observed • Humpback whale/rough-toothed dolphin multi-species group observed • Humpback whale/rough-toothed dolphin/ pilot whale multi-species group observed • Hawaiian monk seal was seen in the water by Kaula Island • 20% of survey time was spent in BSS ≥4

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
35	Marine mammal tagging 16–20 February 2011	Kauai, Kaula Island, Niihau	• Deploy satellite tags on cetaceans near PMRF during SCC	• Non-random, non-systematic survey • Photo-identification • Satellite tagging	• bottlenose dolphin • humpback whale (not systematically recorded) • short-finned pilot whale • spinner dolphin • rough-toothed dolphin	• 364.1 km of trackline • 25.5 hours of observation • 13 sightings other than humpback whale or unidentified large whale, seven sightings of rough toothed dolphin (more than expected) • Three adult male short-finned pilot whales tagged, tags lasted from 30.9 to 37.1 days, two tags collected location only and one tag collected location and dive depth information • The tagged pilot whales appeared to be from three different social units, based on movement patterns • Based on photo-identification, one pilot whale sub- group had no previous sightings; another sub- group had been sighted previously off the island of Oahu. • One tagged pilot whale spent some time off of the west side of Oahu as well as around Kauai. • All three groups of pilot whales appeared to be utilizing habitat within and adjacent to PMRF, within the monitoring period. This suggests that the area north of the channel between Niihau and Kauai may have importance to this species.
36	Aerial surveys 16–19, 24, 26, 28 February & 5 March 2011	PMRF, Shorelines of Kauai, Niihau, Maui, Molokai, Kahoolawe, Lanai, and	• Monitoring before, during, and after SCC • Observe marine species in the area to	• Aerial visual sampling using distance sampling methodology o Line-transect pattern survey	• bottlenose dolphin • false killer whale • humpback whale • short-finned pilot whale	• 46.1 hours of observation (24.5 hours associated with SCC, 13.25 hours with Navy vessel) • 5,675 km of total trackline • 305 sightings, 227 were humpback whales, 48 were turtles near shore

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
		the west coast of Hawaii Island	determine distribution and abundance • Report surface behavior of marine mammals with respect to Navy vessel being tracked • Assess the occurrence, distribution, and behavior of marine mammals and sea turtles using near-shore line transects • Identify stranded cetaceans on shorelines	o Shoreline survey • Orbital survey accompanying Navy vessel • Photo-identification of species • Focal group sampling o Scan sampling • Support tagging effort by supplementing sightings (row 35)	• sperm whale • spinner dolphin • unidentified delphinid • unidentified whale • unidentified turtle sp.	• Four sightings of humpback whales observed while accompanying Navy vessel. Focal follow footage was obtained for one of those sightings. • Aerial team assisted tagging team with three sightings (row 35) • 30% of survey time was spent in BSS ≥4
37	Small vessel survey 26–27 April 2011	Puuloa UNDET range near Pearl Harbor	• Monitor for presence of marine mammals and turtles during UNDET events on the Puuloa UNDET range	• Scan sampling from vessel • Photo-identification	• green turtle	• 5.6 hours of observation • Four explosive events monitored • Seven sighting, four sightings occurred while transiting to and from UNDET range • One UNDET event was delayed to allow turtles to leave area • Green turtles were observed mating in Pearl Harbor and near the Pearl Harbor entrance channel
38	Medium vessel survey 30 June 2011	Kaula Island, south of Niihau	• Monitor area near PMRF • Observe marine species in the area	• Line-transect survey • Distance sampling • Photo-identification	• bottlenose dolphin • rough-toothed dolphin • spinner dolphin	• 508.72 km of trackline • 34.7 hours of observation • 19 sightings • Hawaiian monk seal was seen in the

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			• Assist with sea bird counts on Kaula Island • Enable deployment of PAM device (row 39)		• Hawaiian monk seal	water by Kaula Island as well as hauled out on a shelf • Monk seal sighing included a juvenile • The spinner dolphin group was seen in the same place during each of three circumnavigations of the island • 20% of survey time was spent in BSS ≥4
39	PAM using range hydrophones 11 June–2 August 2011	PMRF	• Acoustically detect marine mammals on the PMRF instrumented range • Direct tagging team to marine mammal sightings (row 41)	• PAM using range hydrophones • Use M3R software to localize cetaceans • Apply algorithms to identify cetacean species	• TBD	• Report not yet generated
E9	**8-9 June2011 - Marine Mammal Monitoring Workshop, public meeting, Arlington, Virginia**					
40	PAM devices 30 June–31 December 2011	Kaula Island	• Monitor for marine mammal presence near Kaula Island	• Moored PAM device		• One EAR deployed ~5 km northeast of Kaula Island • Deployed during medium vessel visual survey (row 38) at a depth of 537 m • 5% duty cycle, sampling rate was 80 kHz • Recording scheduled for 6 months, device recorded for 6 months • Analysis not yet accomplished
41	Marine mammal tagging 21 July–8 August 2011	PMRF, Kauai, Niihau	• Deploy satellite tags on cetaceans near PMRF prior to SCC	• Non-random, non-systematic survey • Photo-identification • Satellite tagging	• bottlenose dolphin • killer whale • pantropical spotted dolphin	• 1,972 km of trackline • 65 sightings, 33 (50.8%) were rough-toothed dolphin • Rare sighting of pod of four killer

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			• Confirm identity of species detected by M3R team (row 39) • Document group composition and behavior	• Coordination with M3R to locate marine mammals (row 39)	• spinner dolphin • rough-toothed dolphin • unidentified dolphin • unidentified odontocete	whales on PMRF • Location-only tags deployed • Coordination with M3R was successful—24 sightings (37%) were cued by acoustic detections from the M3R system • Four tags deployed; three on rough-toothed dolphin, one on bottlenose dolphin • This effort was the first remote deployments of satellite tags on rough-toothed dolphins anywhere in the world. The tags broadcasted for 7.6 to 18.5 days. • All three rough-toothed dolphins remained strongly associated with the islands of Kauai and Niihau, with movements centered on the PMRF range. • Evidence suggests tagged individual rough-toothed dolphins were from two different social groups • Same individual pantropical spotted dolphin observed with a group of spinner dolphin on three separate days • The satellite tagged bottlenose dolphin was the first of this species remotely tagged with a satellite tag in Hawaiian waters. The tag broadcasted for 34 days. The animal stayed closely associated with Kauai.
42	PAM devices 26 July–2 November 2011	Niihau	• Monitor for marine mammal presence near PMRF	• Moored PAM device		• Three EARs deployed around Niihau • Deployed at a depth of 737 m on east side, 766 m on southwest side, and

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						526 m on northwest side • 10% duty cycle, sampling rate was 80 kHz • Recording scheduled for 6 months, all three devices recorded for 3.2 months • Analysis not yet accomplished
43	Small vessel survey 10, 11 August 2011	Puuloa UNDET range near Pearl Harbor	• Monitor for presence of marine mammals and turtles during UNDET events on the Puuloa UNDET range	• Scan sampling from vessel • Photo-identification	• spinner dolphin • green turtle • unidentified turtle sp.	• 5.6 hours of observation • Three explosive events monitored, two on 10 August, one on 11 August • Seven sightings, four sightings occurred while transiting to and from UNDET range • One UNDET event was delayed to allow a turtle to leave area • Dolphins were seen in transit back to Pearl Harbor on 11 August after UNDET events were completed • BSS was 4 during entire monitoring
E10	**22–23 September 2011 – Navy Passive Acoustic Monitoring Working Group, Scripps Institute of Oceanography, La Jolla, California**					
44	Small vessel survey 19, 26 October & 2 November 2011	Puuloa UNDET range near Pearl Harbor	• Monitor for presence of marine mammals and turtles during UNDET events on the Puuloa UNDET range	• Scan sampling from vessel • Photo-identification	• Hawaiian monk seal • green turtle	• Seven explosive events monitored, two each on 19 and 26 October, three on 2 November • Four sightings; two sightings occurred while transiting to UNDET range • One UNDET event was delayed to allow a turtle to leave area • One UNDET event was delayed to allow a monk seal to leave area • A monk seal was observed eating a large fish on the Puuloa UNDET range • BSS was <4 except as the second UNDET event occurred on 19

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						October.
E11	**20 October 2011 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
45	MMOs on Navy vessel 12–16 November 2011	PMRF, Kauai, Oahu, channel between Kauai and Oahu	• Collect data to assess the effectiveness of the Navy LO team • Collect data on marine mammals observed during operations • Obtain data to characterize the possible exposure of marine species to MFAS	• Distance sampling • Photo-identification of species	• rough-toothed dolphin • short-finned pilot whale • unidentified dolphin • unidentified whale	• 48.43 hours of observation • Six sightings during embark, four were short-finned pilot whale • Vessel was a destroyer • two of the sightings by the MMOs were potential trials for the effectiveness study • 54% of observation time was spent in BSS ≥4
46	Marine mammal tagging 10–19 January 2012	PMRF, Kauai, Niihau	• Deploy satellite tags on cetaceans near PMRF prior to SCC • Coordinate with large survey vessel (row 48) • Confirm identity of species detected by M3R team (row 47) • Document group composition and behavior	• Non-random, non-systematic survey • Photo-identification • Satellite tagging • Coordination with M3R to locate marine mammals (row 47)	• Blainville's beaked whale • bottlenose dolphin • rough-toothed dolphin • short-finned pilot whale • spinner dolphin	• 656 km of trackline • 13 sightings • Location-only tags deployed • Four sightings (31%) were cued by acoustic detections from the M3R system, thus providing visual confirmation of acoustically detected species • First visual confirmation of acoustically detected Blainville's beaked whale on PMRF range • Coordinating with the large vessel (row 48) facilitated tracking groups of cetaceans. Coordination between the large vessel and the tagging team allowed the beaked whale group to be re-sighted several times. • Three tags deployed, two on pilot

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						whales, one on rough-toothed dolphin • The pilot whale tags broadcasted for 11.7 and 73.2 days. • Although tagged in same group the two pilot whales showed movements that suggested they were from different social groups. Social network analysis from photo-identification supports this conclusion. • The rough-toothed dolphin tag broadcasted for 27.5 days. The individual had been previously documented off islands of Kauai and Hawaii—an unusual situation for rough-toothed dolphins as most individuals seen on Kauai have only ever been seen on Kauai • 69% of survey time was spent in BSS ≥3
47	PAM using range hydrophones 10–20 January 2012	PMRF	• Acoustically detect marine mammals on the PMRF instrumented range • Direct tagging team (row 46) and large survey vessel (row 47) to marine mammal sightings	• PAM using range hydrophones • Use M3R software to localize cetaceans • Apply algorithms to identify cetacean species	• Blainville's beaked whale • bottlenose dolphin • rough-toothed dolphin • short-finned pilot whale • sperm whale • spinner dolphin	• Five species were visually verified by the tagging team (row 46) and/or large survey vessel (row 48) • Tagging team (row 46) and large survey vessel (row 48) obtained the first visual confirmation of acoustically detected Blainville's beaked whale on PMRF range • Based on experience from 2011, M3R acoustic observers were able to differentiate and identify both rough-toothed dolphin and bottlenose dolphin by visual examination of spectra and time domain waveforms • Based on preliminary analysis of M3R acoustic data, the maximum concentration of Blainville's beaked

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						whales on PMRF appears to be on the northern edge of BARSTUR
48	Large vessel visual survey 11–19 January 2012	PMRF, Kauai, Niihau	• Observe marine species near PMRF before SCC • Document group composition and behavior support the team deploying satellite tags on cetaceans from a small vessel (row 46) • Confirm identity of species detected by M3R team (row 47)	• Non-random, non-systematic survey • Photo-identification • Coordination with M3R to locate marine mammals (row 39) • Acoustic localization using ISHMAEL software • DiFAR sonobuoys	• Blainville's beaked whale • bottlenose dolphin • humpback whale • minke whale • rough-toothed dolphin • short-finned pilot whale • sperm whale • spinner dolphin • Mesoplodon sp. • Unidentified delphinid • Unidentified mysticete • Unidentified cetacean	• 1,330 km of trackline • 96 hours of effort • 161 sightings, 122 (75.8%) were humpback whales • Four sightings of Blainville's beaked whales—an unexpectedly high rate of sightings; one juvenile was observed breaching multiple times as it approached the ship • First visual confirmation of acoustically detected Blainville's beaked whale on PMRF range • Rare sighting of a minke whale on PMRF • Sonobuoys were deployed to obtain recordings of marine mammal vocalizations and to localize marine mammals • The large vessel was able to assist the tagging team (row 46) when tracking groups of cetaceans • The M3R team was able to guide the survey vessel to locations of important sightings of several species, including Blainville's beaked whale • BSS conditions were >3 for much of the survey
49	PAM devices 26 January–1, 5, 7 May 2012	Niihau	• Monitor for marine mammal presence near PMRF	• Moored PAM		• Three EARs deployed around Niihau • Deployed at a depth of 740 m on east side, 791 m on southwest side, and 527 m on northwest side

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
						• 5% duty cycle, sampling rate was 80 kHz • Recording scheduled for 6 months, all three devices recorded for 3.1–3.3 months • Analysis not yet accomplished
50	MMOs on Navy vessel 12–18 February 2012	PMRF, Kauai, Oahu, channel between Kauai and Oahu	• Collect data to assess the effectiveness of the Navy LO team • Collect data on marine mammals observed during operations • Coordination with the contracted aerial survey team (row 51) • Obtain data to characterize the possible exposure of marine species to MFAS	• Distance sampling • Photo-identification of species	• humpback whale • short-finned pilot whale • unidentified whale • unidentified cetacean	• 48.43 hours of observation • 14 sightings during embark, six were humpback whales • Vessel was a destroyer • 10 of the sightings by the MMOs were potential trials for the LOE study • 58% of observation time was spent in BSS ≥4

51	Aerial surveys
	15–18, 23, 25 February 2012
		PMRF, Shorelines of Kauai, Niihau	• Monitoring during and after SCC
			• Observe marine species in the area to determine distribution and abundance
			• Report surface behavior of
				• Aerial visual sampling using distance sampling methodology
				  o Line-transect pattern survey
				  o Shoreline survey
				• Orbital survey accompanying Navy vessel
					• Hawaiian monk seal
					• humpback whale
					• spinner dolphin
					• unidentified delphinid sp.
					• green turtle
						• 29 hours of observation, 14 hours with Navy vessel
						• 5,675 km of total trackline
						• 230 sightings, 188 (82%) were humpback whales, 21 were monk seals hauled out, 15 were turtles near shore
						• Nine sightings observed while accompanying Navy vessel, seven humpback whales, one unidentified

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			marine mammals with respect to Navy vessel being tracked • Confirm identity of species detected acoustically by acoustician listening to the range hydrophone array • Identify stranded cetaceans on shorelines	• Focal group sampling o Scan sampling		blackfish, one unidentified turtle • Focal follow video footage was obtained for four humpback whale pairs in the vicinity of the Navy vessel. Animals remained within four to 10 km of the vessel during filming. Video session ranged from 11 to 30 minutes. • Three acoustic detections were investigated for an acoustician listening to the range hydrophone array. Humpback whales were visually verified by the aerial team. The other two detections could not be visually verified. • Number of monk seals observed was high and unexpected. Use of helicopter for 1 day of shoreline surveys may have improved detection of turtles and hauled out monk seals. • 38% of survey time was spent in "unfavorable sighting conditions"
52	PAM device 25 April–16 May 2012	Kaula Island	• Monitor for marine mammal presence near Kaula Island	• Moored PAM	• TBD	• One EAR deployed ~5 km northeast of Kaula Island • Deployed at a depth of 538 m • 5% duty cycle, sampling rate was 80 kHz • Recording scheduled for 6 months, devices recorded for 0.7 month • Analysis not yet accomplished
53	PAM using range hydrophones 11 June–2 August 2012	PMRF	• Acoustically detect marine mammals on the PMRF instrumented range	• PAM using range hydrophones • Use M3R software to localize cetaceans • Apply algorithms to	• TBD	• Report is in process

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			• Direct tagging team to marine mammal sightings (row 54)	identify cetacean species		
54	Marine mammal tagging 12 June–2 July 2012	PMRF, Kauai, Niihau	• Deploy satellite tags on cetaceans near PMRF prior to SCC • Confirm identity of species detected by M3R team • Document group composition and behavior	• Non-random, non-systematic survey • Photo-identification • Satellite tagging • Coordination with M3R to locate marine mammals (row 53)	• bottlenose dolphin • false killer whale • pantropical spotted dolphin • rough-toothed dolphin • short-finned pilot whale • spinner dolphin • unidentified dolphin	• Report is in process • 67 sightings, 34 (51%) were rough-toothed dolphins • Eight tags deployed: three on false killer whales (two location-only tags, one location and dive tag), two on bottlenose dolphins (one location-only tag, one location and dive tag), and three on rough-toothed dolphins (all location and dive tags). The three tags deployed on false killer whales transmitted for 16, 22, and 42 days • The false killer whales were probably from the NWHI population and were tagged close to the east side of PMRF. • After tagging, the false killer whales stayed in the area of PMRF, Niihau, and the north shore of Kauai for less than 2 days and then swam to the area around Nihoa, Necker, French Frigate Shoals, and Gardner Pinnacles in NWHI.
55	Medium vessel survey 6 July 2012	Kaula Island, south of Niihau	• Monitor area near PMRF • Observe marine species in the area • Assist with sea bird counts on Kaula Island	• Line-transect survey • Distance sampling • Photo-identification • Digital recording using a hydrophone	• bottlenose dolphin • spinner dolphin • Hawaiian monk seal	• 10.3 hours of observation • Four sightings • Three Hawaiian monk seals were hauled out on a shelf of Kaula Island • The spinner dolphin group was seen in the same place during each of three circumnavigations of the island. This

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/Conclusions
			• Record marine mammal vocalizations with a dipping hydrophone			pattern was observed on a previous survey (row 38). • One spinner dolphin identification was matched between this survey and a June 2011 Kaula Island survey (row 38). • The bottlenose dolphin group was re-sighted in the same place during a second circumnavigation of the island. • One bottlenose dolphin identification was matched between this survey and a June 2011 Kaula Island survey (row 38). • One ~7.5 minute acoustic recording of a group of spinner dolphins was collected. • 100% of survey time was spent in BSS ≥5
56	PAM devices 21 July–TBD 2012	Niihau	• Monitor for marine mammal presence near PMRF	• Moored PAM		• Three EARs deployed around Niihau • Deployed at a depth of 737 m on east side, 769 m on southwest side, and 527 m on northwest side • 5% duty cycle, sampling rate was 80 kHz • Recording scheduled for 6 months • Devices not yet retrieved
E12	**10–11 September 2012 – Expert Workgroup Data Analysis Planning Meeting, HDR|EOC Offices, San Diego, California**					
E13	**25 October 2012 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					

Notes: BARSTUR = Barking Sands Tactical Underwater Range, COMPACFLT = Commander, U.S. Pacific Fleet, dB = decibels, DiFAR = Directional Frequency Analysis and Ranging, EAR = Ecological Acoustic Recorder, EEZ = Exclusive Economic Zone, HICEAS = Hawaiian Islands Cetacean and Ecosystem Assessment Survey, HRC = Hawaii Range Complex, kHz = kilohertz, km = kilometers, LO = lookout, LOE = Lookout Effectiveness, m = meters, M3R = marine mammal monitoring on Navy ranges, MFAS = mid-frequency active sonar, MHI = main Hawaiian Islands, MMO = marine mammal observer, nm = nautical miles, NMFS = National Marine Fisheries Service, NWHI = Northwestern Hawaiian Islands, PAM = passive acoustic monitoring, PMRF = Pacific Missile Range Facility, re 1 µPa = referenced to 1 micropascal, RIMPAC = Rim of the Pacific, SCC = Submarine Commanders Course, SD = standard deviation, SINKEX = sinking exercise, SPL = sound pressure level, TBD = to be determined, ULT = unit level training, UNDET = underwater detonation, USWEX = undersea warfare exercise, XBT = expendable bathythermograph

3.2.1 EVOLUTION OF METHODOLOGY

Even a casual glance at all three panels of the visual timeline provides a general sense of the way that the marine species monitoring program has evolved in the HRC. Prior to the implementation of TAP, Phase 1 monitoring, vessel and aerial visual surveys were the primary methods of data collection. Until the second year of the TAP, Phase 1 monitoring, acoustic monitoring had only been performed for Navy projects using towed arrays in conjunction with vessel surveys (Boxes 1 and 11 on the timeline). Tagging for Navy monitoring had not yet been attempted. 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 Pacific Missile Range Facility (PMRF) as well as autonomous moored recording devices (a model known as the Ecological Acoustic Recorder [EAR]). Tagging and acoustic monitoring have become staples for supplying monitoring data and have become relied upon to the same degree as vessel visual surveys, while aerial visual survey methods have become used less frequently and in specific circumstances to achieve certain goals.

Up to 2010, a major focus of monitoring effort 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 month-long training (Boxes 2 and 3 in 2006, Boxes 8 and 9 in 2008, Boxes 23–28 in 2010). But RIMPAC proved to be too big: the training events were widely scattered and obtaining information from many international navies was challenging. In addition, monitoring efforts had to be restricted to small areas where training activities were not occurring. In the HRC, the Navy turned its focus to the more dependable regular training events that had also been the subject of some monitoring. The Submarine Commanders' Course (SCC), a multi-unit training event that occurs every February and August on PMRF, was an ideal sized event, consistently scheduled, that includes the regular use of MFAS. The focus on this type of training event is discussed in detail in Section 3.3. The SCC became the focus of a new aerial monitoring method: the orbital survey near a Navy vessel (the first time is Box 10). In this methodology, an aerial survey team flew elliptical orbits approximately two kilometers (km) in diameter in front of a Navy vessel. The aerial team was looking for marine species in the vicinity of the Navy vessel in order to observe the behavior as the ship approached and supply information that would allow acousticians to estimate the level of sound the animals received (if any) from MFAS. The SCC in HRC was also the first place the Navy Lookout Effectiveness (LOE) study was implemented (Boxes 21 and 22).

The aerial monitoring near Navy vessels is a methodology that has attempted to solve a challenge that has been difficult for the Navy: obtaining data on the behavior of marine species close to Navy vessels. This was originally attempted with boats monitoring in the general vicinity of Navy vessels (Boxes 6, 8, and 29). While the monitoring boat could keep a Navy vessel in sight, once they managed to find it, the vessel was separated from the Navy vessel by many miles. This spatial arrangement was necessary for safety purposes, and the monitors did not observe any notable behavior changes. In HRC, the Navy stopped trying to use vessels for monitoring around Navy vessels and moved to relying on the aerial survey teams and PAM.

At the beginning of calendar year 2011 (during the third monitoring year), after assessment of the monitoring program in an October 2010 meeting in Washington DC to review the first 2 years of TAP, Phase 1 monitoring, the Navy attempted a sophisticated arrangement of "layering" monitoring methods during a February SCC (Boxes 34 to 36 on the timeline). The layered elements included a visual survey that was conducted near PMRF on a 96-foot (ft.) vessel (Box 34), a tagging team assisted by the visual survey boat (Box 35), a replication of the LOE Study on a Navy destroyer (Box 33), and an aerial survey team that flew standard transect patterns and elliptical orbits (Box 36) near the vessel conducting the LOE Study, and assisted the tagging vessel on 1 day. Synergy between the teams proved to be useful, and layering has become a standard practice in Navy monitoring (Department of the Navy 2008). The success of layering is also partially a product of changes the Navy made to the way it contracted much of the monitoring work conducted by parties outside the Navy. In April 2010 (the second year of HRC monitoring), Naval Facilities Engineering Command Atlantic established a 5-year contract for monitoring services. The contract created a single point of contact for obtaining the services of many marine science experts and considerably increased the ease with which multiple complex monitoring endeavors could be planned and coordinated. Prior to this time, contracts were let to specific service providers on an individual effort basis, requiring separate contracts for each monitoring action. Under the new contract, multiple actions could be gathered under a single task order, and execution and reporting was overseen by a central management group.

In July 2011, the Navy implemented a combination of monitoring methods at PMRF that had already proved successful on a larger scale at other Navy ranges such as Atlantic Undersea Test and Evaluation Center (AUTEC) and Southern California Offshore Range (SCORE). The marine mammal monitoring on Navy ranges (M3R) system, run by the Naval Undersea Warfare Center (NUWC), was installed at PMRF. It is being used in combination with on-water expert observers. By combining methods, cetacean physical behavior, group size, and group composition can be documented in parallel with vocal behavior. At the same time satellite tags are being placed on animals to document their broad scale movement and dive behavior. This acoustic and visual cross-validation allows verification of cetacean behavior while at the same increasing the probability of on-water encounters. This is especially important with deep diving species like Blainville's beaked whale (*Mesoplodon densirostris*) which spend little time at the surface and present a small surface profile. This combined approach has improved and increased the identification of marine mammal species on PMRF by directing visual teams to vocalizing animals thus increasing the number of sightings and tagging opportunities (Boxes 39 and 41 in 2011, Boxes 46, 47, 48, 53, and 54 in 2012). Vessels used for tagging are small, nimble craft that carry crew close to the water surface and enable high-quality photo-identification data collection. This lower profile reduces the distance that tagging teams can effectively search for sightings, however. Other vessels, such as medium or large ships or aircraft, have a height advantage that can allow MMOs to spot marine species at greater distances and to track species that dive and resurface during an encounter. A combination of a small tagging vessel and a larger support vessel has been utilized successfully several times (Boxes 34 and 35 in 2011, pictured in Figure 3.2-2; Boxes 46 and 48 in 2012).

The M3R system has a spatial advantage that no other survey platform can match. In a brief period of time, the system can survey the entirety of PMRF and, in specific cases, localize vocalizing marine mammals. This synoptic view of PMRF has led to increased sightings of species. As stated above, there is a complementary benefit for tagging and the M3R system. The tagging team can visually validate species for M3R, and M3R can guide the tagging team to the location of species. For example, during a July–August tagging effort on PMRF in 2011, 37 percent of sightings were cued by acoustic detections from the M3R system (Box 41), and in January 2012 on PMRF 31 percent of sightings were cued by acoustic detections from the M3R system (Box 46). Also in January 2012, M3R worked with an MMO team on a large Military Sealift Command ship to observe marine mammals far out on the range, including a remarkable

Figure 3.2-2: A Navy Scientist Photographing Marine Species from 96-foot Vessel that Assisted a Tagging Team in February 2011. A short-finned pilot whale is in the foreground. Three individuals of this species were tagged during this monitoring effort (Boxes 34 and 35). Photo by Jessica Aschettino under NMFS permit #15330.

four sightings of Blainville's beaked whale (*Mesoplodon densirostris*) in 9 days—a surprising number of encounters for a species that had been heard but not observed during surveys on the range up until that time (Boxes 46–48).

M3R passive acoustics are particularly well developed for the broad-scale monitoring of beaked whales. Data from the system are being used in an effort to estimate the abundance and document the distribution of Blainville's beaked whale with and without sonar present on the PMRF range. Broad scale movement of Blainville's beaked whales have been documented at AUTEC (Moretti et al. 2010, McCarthy et al. 2009, Tyack et al. 2009). Currently, studies are underway to determine if such behavior is occurring on the PMRF range. M3R passive acoustics is relegated to the PMRF instrumented range. For this reason, satellite tags are being attached to animals to document mid-term movement (months) and dive behavior.

3.2.2 Monitoring Highlights

The Navy marine species monitoring program is in a unique position to witness protected species. Besides NMFS, no other entity goes to sea in relatively remote locations on a systematic basis to observe and record the presence and behavior of protected marine species. Scientists who participate in monitoring have sighted rare and difficult-to-observe species in HRC. Although rare sightings are anecdotal, they provide insight into some species for which little data exists in the HRC. Examples include baleen whales that are thought to visit the area around Hawaii in the winter, but solid patterns have not been established for the species. Minke whales (*Balaenoptera acutorostrata*) are often detected acoustically around Hawaii in the winter (Norris et al. 2012), but rarely seen. A visual survey sighted minke whales south of PMRF during February 2005 (Box 1, Norris et al. 2005). Two scientists working on an acoustic monitoring project of minke whales on PMRF observed a single minke whale on PMRF (Department of the Navy 2011b). Navy monitors also sighted a minke whale during a major monitoring effort on PMRF during January 2012 (Box 48 and Figure 3.2-3). These sightings help to establish that

Figure 3.2-3: A Minke Whale Observed on PMRF in January 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. Photo by Mark Deakos under NMFS permit #14451.

minke whales may be regular visitors to Hawaii in the winter and that they occur in the vicinity of PMRF. While Sei whales (*Balaenoptera borealis*) are not frequently seen in Hawaiian waters, they have been observed several times during Navy monitoring, including more than one sighting north of Oahu during November 2007 (Box 6, Figure 3.2-4) and near Perret Seamount in November 2010 (Box 29, Figure 3.2-1). The first-ever recorded sighting of a Bryde's whale (*Balaenoptera edeni*) in Hawaiian waters occurred at the same time as the sei whale sightings in 2007 (Box 6, Figure 3.2-5). A focal follow was obtained from the Bryde's whale while a Navy ship trained just over the horizon.

Green turtles (*Chelonia mydas*) are the species of sea turtle that are most commonly observed in the Hawaiian Islands, but occasionally other species are seen. A rare of sighting of a leatherback sea turtle (*Dermochelys coriacea*) occurred during a shore survey in the summer of 2006 (Box 3). This is a particularly notable sighting, because the individual was seen close to land.

Figure 3.2-4: A Sei Whale Observed North of Oahu in November 2007. Photo from Cetos Research Organization under NMFS permit #1039-1699.

Figure 3.2-5: The First Confirmed Sighting of a Bryde's Whale in Hawaiian Waters. It was seen north of Oahu in November 2007. Although difficult to see, there are three rostral ridges on this species. Photo from Cetos Research Organization under NMFS permit #1039-1699.

A number of odontocetes occur in Hawaiian waters, and the various scientific projects and programs that work in the field report sightings of many species with some regularity. A rare sight is killer whales (*Orcinus orca*), and a tagging team observed a group of killer whales on PMRF in July 2011 (Box 41, Figure 3.2-6). Because certain species of odontocetes can be seen frequently in Hawaiian nearshore waters, regular monitoring has the chance of picking up on patterns in odontocete presence. Locations such as Kaula Islet, PMRF, and the Puuloa UNDET range are visited with regularity and some repeated sighting patterns may be emerging. Photo-identified spinner dolphins (*Stenella longirostris*) and bottlenose dolphins (*Tursiops truncatus*) have been matched between years for sightings near Kaula Islet (Figure 3.2-7). As with other locations in the Hawaiian Islands, there may be a population of these species that are associated with this island or a small network of islands and shoals (Baird et al. 2012b). Kaula Islet also appears to be a haulout location for Hawaiian monk seals. When fins have been visible, all seals observed at Kaula have been determined to be untagged by PIFSC. Individuals have been seen on the ledges or in the water immediately adjacent to the island on all surveys except one (July 2009, Box 16; February 2011, Box 34, in water; June 2011, Box 38, in water and hauled out; July 2012, Box 55, hauled out).

In 2010, MMOs observed a trio of false killer whales near PMRF (between Niihau and Kaula Islet) that included an adult male, an adult female, and a calf (Box 23, Figure 3.2-1). Researchers at CRC compared the photos to the catalog of individuals from the MHI insular population and concluded that the individuals did not match any identities in the catalog (Baird pers comm. 2010). Because the insular population is known to be comprised of a very small number of individuals (~150, Baird unpublished data), this suggested the false killer whales were either from a pelagic population or the Northwestern Hawaiian Islands (NWHI) population. In June

2012 during a tagging project at PMRF (Box 54), CRC researchers encountered a group of false killer whales on subsequent days and were able to photo-identify most individuals and deploy three tags. Satellite data showed that the group left the area of PMRF, Niihau, and Kauai after few days and moved to Nihoa, Necker, French Frigate Shoals and Gardner Pinnacles in the NWHI (Baird 2012). These three sightings comprise a sparse body of evidence that suggests the area between Kauai and Nihoa is visited by false killer whales from populations other than the MHI insular distinct population segment.

Figure 3.2-6: A Rare Sighting of a Pod of Killer Whales in the Hawaiian Islands, July 2011. Photo from CRC under NMFS permit #15330.

Figure 3.2-7: Matching Dorsal Fin Photos for a Spinner Dolphin Seen near Kaula Islet. Photos by Morgan Richie.

Navy monitoring is not only concerned with documenting the occurrence of marine species but also behavior, particularly in the presence of Navy assets. While assessing behavioral patterns requires long time series data to establish behavioral baselines and to determine behavioral changes, some notable behaviors are observed anecdotally. Monitoring on the Puuloa UNDET range near Pearl Harbor sometimes allows for close observation of marine species because it is relatively shallow, a small area is being monitored, and it is near a region of relatively high human use, so the animals in the area may be more habituated to human presence. Green turtles are the most regularly observed species of concern in the area during monitoring. In April 2011, a unique sighting was two different pairs of greens mating in an area that was outside the UNDET range and close to the entrance of Pearl Harbor (Box 37, Figure 3.2-8) as well as another pair inside the harbor. Another unusual sighting on the UNDET range was the observation in October 2011 of a Hawaiian monk seal at the surface of the water swallowing a large fish (Box 44, Figure 3.2-9). Apparently the fish was challenging to swallow because more than one attempt was made before the entire fish was ingested. Photos of the event were provided to NMFS PIFSC for species identification of the fish for Hawaiian monk seal prey analysis, of which little is known in the MHI. The monk seal was identified as RH58 and is nicknamed "Rocky."

Figure 3.2-8: A Pair of Green Turtles Mating near Pearl Harbor. This pair was seen after UNDET monitoring on the Puuloa UNDET range. Photo by Morgan Richie.

During a large vessel survey on PMRF in January 2012 (Box 48), a juvenile Blainville's beaked whale approached the survey vessel while repeatedly breaching (Figure 3.2-10). This species is notorious for being difficult to detect at the surface due to keeping a low profile and rarely engages in such breaching behavior. This sighting was all the more unexpected because the sighting conditions were Beaufort sea state (BSS) five, conditions that are notoriously bad for observing cryptic species such as beaked whales.

Figure 3.2-9: Hawaiian Monk Seal, RH58 or "Rocky," Eating a Large Fish on the Puuloa UNDET Range. Photo by Robert Uyeyama.

Figure 3.2-10: A Breaching Juvenile Blainville's Beaked Whale. This individual breached repeatedly on PMRF near a Navy monitoring vessel in January 2012. Photo by Mark Deakos under NMFS permit #14451.

Navy marine species monitoring provided for a "first time" tagging event in August 2011. On PMRF, CRC executed the first remote deployments of satellite tags on rough-toothed dolphins anywhere in the world (Box 41, Figure 3.2-11). Three tags were deployed and all three rough-toothed dolphins remained strongly associated with the islands of Kauai and Niihau, with movements centered on the PMRF range.

Figure 3.2-11: The First Rough-Toothed Dolphin Ever Remotely Satellite Tagged (August 2011). The Low Impact Minimally Percutaneous External-electronics transmitter (LIMPET) tag is visible on its dorsal fin. This individual has an unusual piebald coloring. Photo by Robin Baird under NMFS permit #15330.

3.3 Submarine Commanders Course as a Centerpiece of HRC Monitoring

This section highlights how the Submarine Commanders Course (SCC) was identified as an optimal training event for monitoring in the HRC.

3.3.1 Submarine Commanders Course

The SCC is an ASW training event where MFAS is utilized. It typically involves two to four surface ships, submarines, P-3s and helicopters. When the HRC monitoring plan (Department of the Navy 2008) was being finalized, the Pacific Fleet operators recommended SCC for aerial monitoring based upon the number of assets involved and the occurrence of the surface ship portion at the PMRF instrumented hydrophone range allowing for safe de-confliction of the aerial survey aircraft from the Navy P 3s and helicopters by range control. In contrast, major training exercises such as RIMPAC and undersea warfare exercise (USWEX) typically involve more surface ships, are of longer duration, are conducted further offshore where no range control exists, and, in many cases, ships do not come in or out of Pearl Harbor before and after the exercise to embark/disembark MMO.

Several monitoring methods were combined from 2009 and 2012 as outlined in Study Questions 1 and 3 in the HRC Monitoring Plan (Department of the Navy 2008). Beginning with aerial surveys, MMO embarked on a Navy surface ship during the event and collected acoustic recordings from the PMRF hydrophones before and after the event (not during). In 2011, approval was obtained for collection of acoustic recordings (classified) during the event. In 2011 and 2012, tagging of cetaceans prior to the event aided by the newly installed M3R system augmented the other methods. The system allows the passive acoustic monitoring of all PMRF hydrophones in real-time and archiving of cetacean detection data for post analysis. Based on these tests, for the first time, passive acoustic detections of what were believed to be Blainville's beaked whales were visually verified to be accurate species identification. Subsequent analyses of these data are beginning to document the presence and distribution of this species.

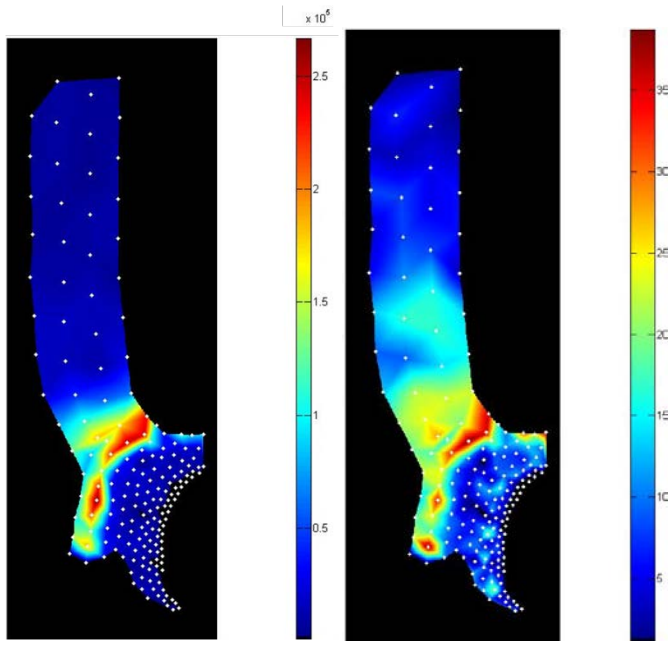


Figure 3.3-1: The plots show the distribution of Blainville's beaked whales clicks during the July, 2012 M3R test. The left plot shows the summed click counts for the test period. The right plot shows the number of times a hydrophone was at the center of a vocalizing Blainville's beaked whale group using a linear interpolation in MATLAB for groups detected on at least two hydrophones.

Tagging and M3R was an added monitoring method that was planned to be executed prior to the SCC. The tags had the potential to contribute to events on PMRF if the tagged animals moved near active Navy assets. Therefore, the layers of monitoring methodologies applied concurrently or near-concurrently include:

- Aerial visual survey, orbiting a Navy surface ship conducting ASW training
- Marine Mammal Observers (MMO) for visual survey embarked aboard the Navy surface ship being followed by the aerial survey
- Acoustic recordings made during training event by the underwater instrumented range, using M3R assets
- Satellite tags applied to marine mammals on/near the range before the commencement of the training event

These components are described in more detail below in Section 1.1.2. Although it was not the original intent to focus much of the annual monitoring effort on one type of training event, SCC was realized to be the optimum event for monitoring due to number of Navy assets involved, occurrence at PMRF, predictable scheduling (e.g., twice annually) and outstanding logistical support from Commander Submarine Force, U.S. Pacific Fleet and PMRF range staff.

3.3.2 METHODOLOGY – VISUAL (MMO/AERIAL/VESSEL), TAGGING, INSTRUMENTED RANGE

Visual (Aerial) – The initial concept for having an aerial survey team fly elliptical orbits in front of a surface ship transmitting MFAS was developed by a small Navy/NMFS team and outlined in the 2008 HRC Monitoring Plan (Department of the Navy 2008). The goal was to gather behavioral data (e.g., focal follows) from marine mammals during a training event. Gathering this information was thought to be essential for answering Study Questions 1 and 3 (Department of the Navy 2008). NMFS Protected Resources Division opined that an aerial platform would be the most effective way to gather behavior and movements from slightly submerged whales that might not be detected using other methods.

For an SCC training event, aerial monitoring involved flying a twin-engine high-wing aircraft at 244 to 305 meters (m) (800 to 1,000 ft.) in elliptical orbits in front of a Navy surface ship involved in the ASW event. When a marine mammals or sea turtles is sighted within approximately 5 km (2.7 nm) of the ship, their initial locations are noted and the survey plane climbs to 457 m (1,500 ft.), an altitude shown to reduce impacts of aircraft noise on the animals' behavior. This change in altitude commences the behavioral focal follow protocol. The focal follow session is documented in each case using a high-definition, hand-held video camera with audio inputted from the intercom system of the plane. The goal is then to circle the focal group for as long as possible, documenting each behavior (e.g., blow, breach, fluke-up dive, etc.). Videos are later transcribed with time stamps for each event using a behavioral ethogram. Variables of interest are subsequently derived for subsequent analyses (e.g., respiration intervals, surface/dive durations, and rates of travel, among others) (Smultea et al. 2009, Mobley and Milette 2010, Mobley 2011).

MMOs were embarked on the same surface ship that the aerial survey aircraft was assigned to enabling them to facilitate communication with the ships' bridge and relay sighting information between the MMO and the aerial survey team via radio. Simultaneously, the MMO conducted the LOE study.[1]

Visual (Vessel) – Visual surveys using both small and large vessels were added to this study in 2011 and 2012. Primary goals for the small boat surveys were to gather data on habitat use and movements of marine mammals near PMRF, provide species verification for acoustic detections by M3R and deploy satellite tags prior to the SCC. On water observers are able to verify the species detected and document the group size and composition, along with surface behavior. These data are critical to the development of species-specific passive acoustic Detection, Classification, and Localization (DCL) algorithms and methods to estimate the species' abundance. At the same time, observers can collect photo identifications and biopsy the animals for post-test genetic and fatty acid analysis. In January 2012, a large, live aboard non-combatant Navy vessel was used as an additional visual platform, allowing for surveys to be conducted further offshore, during all daylight hours and in rougher conditions.

[1] Study Question 5 (aka "Lookout Effectiveness Study") from the HRC monitoring plan (Department of the Navy 2008) – "Is the Navy's suite of mitigation measures for MFAS and explosives effective in avoiding injury and mortality of marine mammals and sea turtles?"

Tagging – A 7.3 m rigid-hulled inflatable boat (RHIB) was used in 2011, 2012 and 2013 at the PMRF range. Survey efforts were coordinated with the M3R program with the research vessel directed to areas with acoustic identifications of odontocetes. Efforts were made to obtain photographs of all individuals in groups of odontocetes encountered and deploy satellite tags when conditions allowed.

Satellite tagging was undertaken with any of a number of priority target species encountered, including false killer whales (*Pseudorca crassidens*), short-finned pilot whales (*Globicephala macrorynchus*), rough-toothed dolphins, and bottlenose dolphins. The satellite tags used were either location only SPOT5 tags or Mk10-A dive depth transmitting tags (Wildlife Computers, Inc., Redmond, WA) in the Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) configuration (Baird et al. 2010). Attachment darts penetrated a maximum of 4.2 centimeters (cm) into the dorsal fin for smaller species (e.g., rough-toothed and bottlenose dolphins) or 6.5 cm into the dorsal fin for larger species (e.g., short-finned pilot whales and false killer whales). Tags were set for differing length deployments, balancing prior knowledge of tagging on each species and the desired outcome of obtaining data before, during, and after the SCC. Data obtained from the Argos system was processed with the Douglas Argos-Filter v. 7.08 (available at Alaska.usgs.gov/science/biology/spatial/douglas.html) using two independent methods: distance between consecutive locations, and rate and bearings among consecutive movement vectors.

Instrumented Range Acoustic Data – The PMRF hydrophone range is instrumented with 199 functional bottom-mounted hydrophones which are divided into three sub-ranges, the Shallow Water Training Range (SWTR), the Barking Sands Tactical Underwater Range (BARSTUR), and the Barking Sands Underwater Range Extension (BSURE). The combined range extends from shallow water (SWTR, 100–1,000 m), to mid-water depths (BARSTUR, ~1,000–2,000 m), to very deep ocean (BSURE, ~2,000–4,000 m). The layout of the hydrophones is optimized for tracking undersea vehicles equipped with a 35 kilohertz (kHz) pinger that emits a known signal at a known repetition rate; consequently, it is well suited for detection of marine mammal vocalizations including those produced by beaked whales.

Acoustic data collected from the PMRF instrumented hydrophone range has been recorded and archived since 2002; analysis began in 2008. Due to classification challenges, these data were initially only recorded on 2 random days during the month when training events were not occurring. In 2010, this data collection was refined to occur on the days before and after a sonar training event. In 2011, Pacific Fleet Environmental secured an agreement with the Commanding Officer of PMRF to record and archive data collected during sonar training events for monitoring analysis enabling analysis to include estimation of RLs and behavioral response.

In 2012, the range hydrophones were further enhanced by the addition of the M3R system, greatly expanding the ranges' monitoring and research capability. The M3R system processes input from the hydrophones in real time. On-shore acousticians observe and characterize species vocalizations using the M3R software "mmammal." This utility allows the user to monitor range activity and to view, on demand, hard-limited, binary spectrograms for hydrophones of interest (Moretti 2012, Dilley and McCarthy 2012).

Two field tests using the M3R system were conducted in the summer and winter of 2012, prior to SCC and RIMPAC (Moretti 2012, Dilley and McCarthy 2012). The primary objectives of the tests were to acoustically detect marine mammals at PMRF and vector visual observers to vocalizing animals. This allowed the team to:

- Visually verify the species identifications for acoustic detections made by the PMRF instrumented range
- Deploy satellite tags on marine mammals prior to SCC and RIMPAC to monitor animals' movement before, during and after Navy training events
- Photograph animals to create a individual-identification record for the HRC
- Document group composition and behavior

3.3.3 ANALYSIS

3.3.3.1 Aerial Focal Follow

Aerial surveys were conducted during five SCC between 2008 and 2012 using survey, focal follow, and video as discussed in HRC annual monitoring reports from 2009 to 2012 (Department of the Navy 2009b, 2010b, 2011b, 2012b).

Eighteen focal follows were conducted during five SCC training events from 2008 to 2012 for a total of 4.5 hr of video recording (Mobley, J.R., et al. 2012 [Appendix B]). Seventeen of the 18 (94 percent) focal follows occurred during February SCC training events (four of the five aerial-monitored SCC events occurred in February). 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. Ten of the 18 (56 percent) focal follows were judged in quality to be "fair" or better (mean duration = 22 minutes; SD = 14.5; range: 2–47 minutes) and four focal follows (25 percent—including one rated "fair" to "good") as "good" or "excellent." RLs were calculated for four of the 18 (22 percent) focal follows, for which MFAS transmission times and positions of marine mammals and ships were available.

Recent analysis, detailed in Appendix B (Mobley, J.R. et al. 2012), layered the focal follow data, and PMRF range products focused on answering the following two monitoring questions:

- Are marine mammals (and sea turtles) exposed to MFAS, and if so, at what levels?
- If marine mammals (and sea turtles) are exposed to MFAS, what are their behavioral responses to various RLs?

Four focal follows involving seven humpback whales overlapped with MFAS transmissions, enabling calculation of estimated RLs. Estimated maximum RLs at focal group locations ranged from 135 to 161 dB re 1 µPa. Two sessions involved exposure to a single MFAS transmission, and two involved exposure to multiple sonar transmissions. Additionally, a case study was analyzed to offer a micro view that can help to identify the link between changes in the environment and corresponding changes in behavior.

The focal follow used in the case study was chosen as the subject for two reasons: (1) based on PMRF hydrophone range monitoring data in conjunction with destroyer (DDG) and whale locations, Pod 1 was exposed to 23 MFAS transmissions during a 20-minute period largely overlapping with the 28-minute period from first to last sighting; and (2) Pod 1 spent the majority of time (approximately 60 percent) visible at the surface. Due to the whales' predominant surface travel, the decision was made to calculate RLs with whale positions modeled at 2, 4, 6, 8, and 10-m depth (Mobley, J.R. et al. 2012 [Appendix B]). The median RL values, behaviors and range from the source are shown in Figure 3.3-2.

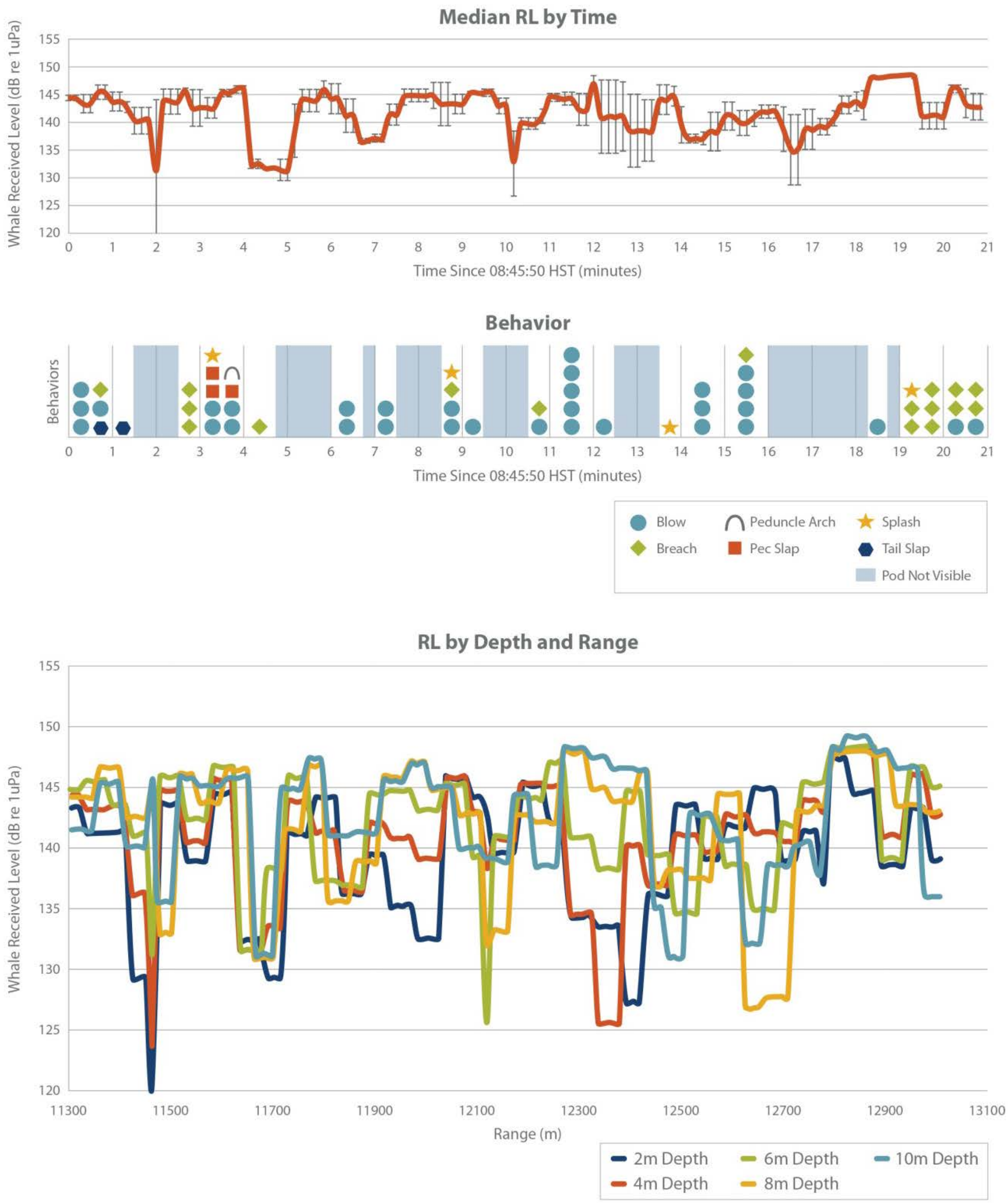


Figure 3.3-2: Whale Behaviors (middle) Correlated with MFAS RLs by Time (top) and Range from Source (bottom). (from Mobley, J.R. et al. 2012 [Appendix B])

Analysis of this case study reveals several noteworthy findings. First, Pod 1 persisted in its northwest heading moving toward the DDG despite exposure to repeated MFAS transmissions throughout the period of observation (i.e., from first to last sighting). The pod remained visible at the surface throughout most of the 21-minute focal follow, which is particularly remarkable given the presence of surface ducting that produced greater noise levels at the water's surface. In light of this, Pod 1 could have theoretically reduced exposure to higher-amplitude MFAS by simply traveling deeper underwater. Finally, the rate of behavior production remained relatively consistent throughout the observation period, with behaviors that are typically seen in the context of the social interactions during the winter breeding season. It is important to note that it cannot be easily ascertained whether the behaviors observed were in response to the DDG, the MFAS transmissions, or the presence of other whales nearby.

With this type of detailed case study approach, one is able to juxtapose changes in the acoustic environment (e.g., variations in RLs) with possible changes in the focal animals' behavior. Though one cannot necessarily draw generalized conclusions from single cases, if other cases show similar responses with changes in acoustic levels, it begins to provide supportive evidence regarding the effects of MFAS on the species in question.

3.3.3.2 Instrumented Range

Analysis of range data shows that it is possible to obtain some of the results being sought by larger behavioral response studies (BRS) on other ranges with a smaller scale effort. The advantage of the SCC over the BRS is that actual MFAS is utilized, vice surrogate sonars with lower source levels. The disadvantages of the SCC are: (1) lack of controls and need to estimate exposure levels as there are no acoustic tags on animals, (2) type and level of resolution of behavior able to be observed is different from an aerial platform as compared to a dive tag, (3) it is uncertain when the first significant exposures to the animals occurred across the course of the training event, (4) thus far the SCC methodology has not been utilized to examine interruption of feeding dives by beaked whales, and (5) density of marine mammals at the waters of the SCC at PMRF is much lower than that at the BRS sites.

2009

Acoustic recordings at PMRF were performed at a rate of 2 days per month; each recording provides approximately 1 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. Prior to 2009, methods were developed to automatically detect beaked whales on the PMRF range. And, in 2009, methods were developed (with leverage from ONR funding) to automatically detect minke whales and efforts for localization and acoustic density estimation efforts were initiated.

Manual methods were used to localize minke whales in near real time and direct a visual sighting team to the animals. Post processing identified a very stable spectral feature for an individual minke whale. And, in addition, the ability to track a minke whale for nearly 6 hours using the PMRF hydrophones was achieved for the first time, which may be useful for future analysis

2010

The 2010 effort focused on beaked and minke whales before and after the February SCC, utilizing automated species passive acoustic detection and classification algorithms (see Martin 2010 in Department of the Navy 2010a for full report). Manual verification of selected automatic detections was performed to confirm presence of the species under investigation. Results indicate presence of beaked whales suspected to be Blainville's, Cuvier's and minke whales before and after the SCC on the PMRF range.

All 126.1 hours of data available for the *pre* and *post* SCC periods was processed for the 13 hydrophones used in the beaked whale analysis and 15 hydrophones utilized in the minke analysis.

Beaked whales: The analysis showed that there were beaked whales (and minke whales) present in the area before, and after, the SCC. No data was recorded during the actual operation, so nothing can be determined for that period. Furthermore, as the normal variations in the number presented here are unknown, it is not possible to determine with any confidence if the numbers convey any statistical significance related to effects of the SCC.

The number of beaked whale clicks indicated lower numbers for the post SCC period over all three pre SCC periods shown. The number of beaked whale clicks detected is highly dependent upon how close to the hydrophones the beaked whale group is when diving. While the number of beaked whale dives (dive vocal periods validated) in the post period is the same as that for the 45.3 hours prior to the SCC, it is higher than the period before the 45.3 hours just prior to the pre SCC. This highlights the need to better understand normal variations of beaked whale dives before arriving at conclusions based solely on *pre* and *post* analysis relative to the SCC between the time periods. The data does show lower numbers of beaked whale clicks detected for the post versus the pre periods; it is not clear if the differences are due to the SCC or normal variations given the spatial under-sampling.

Minke: This study shows the presence of boing vocalizing minke whales for both the *pre* and *post* SCC periods in terms of the automatic minke boing detections per hour using 15 hydrophones. While there is some evidence of potentially suppressed boing rates (i.e., the first 10 hours of the *post* SCC period where rates steadily rise from a low initial value), a similar situation existed in the final portion of the *pre* SCC period. The large variations in boing rates observed in both the *pre* and *post* SCC periods needs to be better understood before arriving at conclusions relative to effects of the event. The use of an automated localization tool suggests the peak in boing rate (*pre* SCC) could be the result of boing rates much more rapid than normally observed when two minke are in close proximity to one another. The boing rate by hydrophone also shows large variations with indication of a depth relationship. The use of fine resolution frequency content of the boing detection shows promise in helping isolate individuals. Density estimation of the minke boing density is possible (Martin 2010); however, the cue rate for converting to vocalizing minke whales is currently unknown.

2011

2011 was the first year in which acoustic recordings were made during the SCC, allowing for conclusions to be drawn regarding the actual exercise period of MFAS exposures, as well as allowing analysis of the M3R data to be layered with other monitoring methodologies also conducted during the event, including visual surveys by aerial platforms, as well as MMOs on Navy ships. The resulting analysis is described below.

During February 2011 SCC, MMOs estimated the location of humpback whales at the surface while the transmitting ship was tracked on the range, enabling estimation of exposures of animals during active MFAS. Animal locations were obtained both from a visual sighting for a small group of unidentified whales and processing of passive acoustic data for one minke whale and one humpback whale. Positions, and estimated headings, of the DDG were obtained from PMRF exercise products (Martin and Kok 2011 in Department of the Navy 2011b).

Results for the average minke boing rate per hour and beaked whale dive rates show animal presence before, during, and after the event. The variability in the average minke boing rate during parts of the SCC is high and shows depressed values. It is unclear if the depressed values are part of normal variation or a result of the SCC activity. Periods of rapid boings are evident in the data which are suspected as being due to two or more calling whales being in close proximity to one another (Thompson and Friedl 1982). Beaked whale presence, as evidenced by detection of beaked whale foraging clicks, is quantified in terms of dives per hour with presence before, during, and after the event with no clear implication related to MFAS activity.

Passive acoustic data was also collected continuously during the SCC from 31 hydrophones. This data showed the presence of cetaceans other than minke and beaked whales including pilot whales, sperm whales, humpback whales, fin whales and sei whales. This is contrast to the visual sightings reported by the MMO.

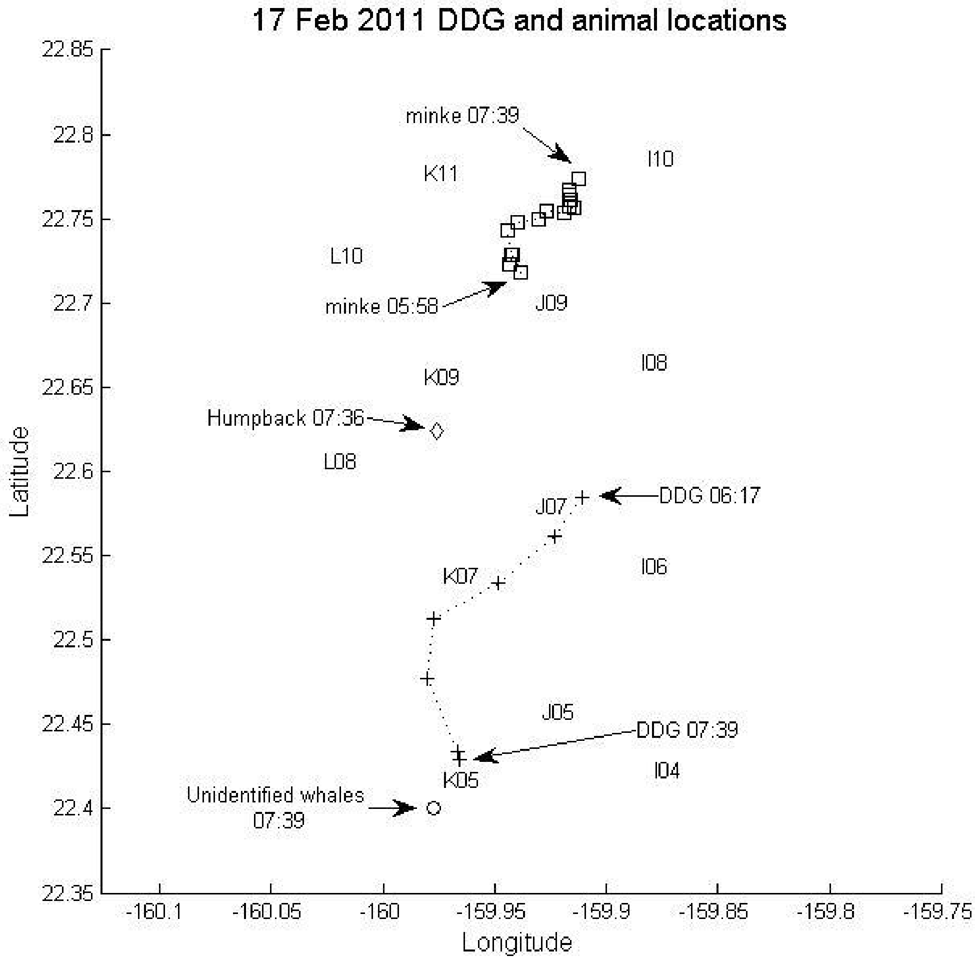


Figure 3.3-2: Plan View of Positions of DDG (+ symbols) and Whales (minke square symbols, humpback single diamond, unidentified group of whales open circle) between 5:58 a.m. Hawaii-Aleutian Standard Time (HST) and 7:39 a.m. HST on 17 February 2011. Closest distance from DDG during MFAS transmits for unidentified whales are 3.4 km at 7:38 a.m. HST, followed by 16.3 km at 6:17 a.m. HST for minke whales followed by 21 km at 7:36 a.m. HST for humpback whale. Note that for the humpback case the whale is nearly astern of the DDG.

Figure 3.3-3 shows a coarse-scale view of the area of the PMRF BSURE range during this analysis period the morning of 17 February 2011. The range hydrophones are labeled as three digits with leading alpha characters (e.g., I10, J09, K11, L10); the DDG ship position is shown as plus signs with labels and arrows to indicate the times. Two additional symbols show the location of the DDG sighting of a group of between three and five unidentified whales (open circle at 07:39), and the single manually derived humpback whale position is shown as an open diamond at 07:36. Localization accuracy is estimated to be approximately +/- 200m for the minke whale; hydrophone geometry is shown using hydrophones J09, I10, K11 and L10 to localize the minke whale. Table 3.3-1 summarizes the estimated sound pressure levels (SPLs) the animal is exposed to from two propagation paths (surface duct / direct and bottom bounce).

Table 3.3-1: Estimated Exposure of Marine Mammals (sound pressure level) for Marine Mammals the Morning of 17 February 2011 as Determined by Sonar Equation and Ray Trace Models for both a Surface Duct, or Direct Path, and one Bottom Bounce of Sound from Seafloor to Animal.

Sound pressure levels exposed to (dB re micro Pascal)				Horizontal Range	Species and time of MFA (HST)
Includes 7 dB of bottom reflection loss			no bottom reflection loss	In meters and rel bearing to ship @ 3k MFA transmission	Ba= minke Mn=humpback unid=unidentified whale
Sonar Equation Model		Ray Trace Model			
suface duct	bottom bounce	suface duct	bottom bounce		
145.6 dB	138.7 dB	no path	148.4 dB	16300 m @ 94	Ba 06:17:18
141.4 dB	136.4 dB	no path	146.7 dB	21000 m @ 167	Mn 07:35:51
162.4 dB	146.2 dB	164.1 dB @ 2.2s dp	154.7 dB @ 6.44 s	3390 m @ 21	Unid 07:38:07

Notes: dB = decibel(s), MFA = mid-frequency active sonar HST = Hawaii-Aleutian Standard Time

The beaked whale automatic detection process performed on data from the February 2010 SCC (Martin 2010 in Department of the Navy 2010) for 13 hydrophones was duplicated on February 2011 SCC data for 16 hydrophones. With the higher frequency response of the new BSURE replacement hydrophones, the beaked whale analysis for this event represents more than a fourfold increase in available data (twice the temporal data and 30 vice 13 hydrophones).

Table 3.3-2 provides results of the validation analysis for beaked whale foraging clicks for the pre SCC period, SCC-Torpedo Exercise (TORPEX) period, SCC-Miniwar period, and post SCC period. One sees similar numbers of dive vocal periods per hour for the pre SCC and SCC Miniwar periods and slightly lower numbers for the SCC-TORPEX and post SCC periods. It is difficult to make any sense out of that relative to MFAS activity (SCC-Miniwar) as the dive vocal periods per hour are similar to the pre-SCC period and higher than both the post-SCC and SCC-TORPEX periods. The number of hydrophones in this analysis does not guarantee detecting beaked whale dives due to limited spatial sampling, thus one simply uses this analysis to indicate that there was beaked whale activity over the range area throughout the time period. This does not fit with what has been seen at AUTEC in terms of beaked whales leaving the area during MFAS activity and returning afterwards. However, the PMRF area is about three times as large as AUTEC and it is possible beaked whales could continue activity distant from MFAS activity, or alternatively that the beaked whales have become acclimated to the MFAS activity.

Table 3.3-2: Summary of Validated Beaked Whale Foraging Clicks Grouped into Dive Vocal Periods for the Pre-SCC, SCC-TORPEX, SCC-Miniwar and Post-SCC

	Pre SCC 11-13 Feb 2011	SCC-TORPEX 14-16 Feb 2011	SCC-miniwar 16-18 Feb 2011	Post SCC 19-22 Feb 2011
Time (hours)	61.67	52	61.67	79.17
Dive Vocal Periods	44	31	49	46
Dive Vocal Periods/h	0.713	0.596	0.795	0.581
BW Clicks in Dives	1831	2062	3269	2245
BW Clicks per Hour	26.69	39.65	53.01	28.36
BW Clicks per Dive	41.61	66.52	66.71	48.80

Notes: SCC = Submarine Commanders Course, TORPEX = Torpedo Exercise, Periods/h = periods per hour

It is interesting to note that there were validated beaked whale clicks from BSURE replacement hydrophones far offshore in water depth near 5000 m. This was previously undetectable as the older BSURE offshore phones did not respond to beaked whale click frequencies.

During the analysis any other species acoustically identified, or suspected, are noted for further review and analysis. This includes humpback whale vocalizations, as there were humpback whales on the range as verified by experienced MMOs on both the DDG and an aircraft. Some low frequency (~35 Hz to 20 Hz) pulse sounds (typically occurring in groups of three at a time) have also been noted during the event which may be attributable to fin or sei whales. This low frequency analysis is much more feasible with the advent of the BSURE replacement hydrophones which were operational around January 2011. Tagged pilot whales (Baird 2011) also were tracked on the range, albeit in the after-event time period. Pilot whale echolocation clicks are often confused with beaked whale clicks by the current beaked whale click detector being utilized. Echolocation clicks from unknown odontocetes were also observed. Sperm whale clicks were sometimes observed throughout the data.

Repeated localizations, such as the minke whale in this case, allowed investigation of both spatial updates of the animals' location with respect to the ship using MFAS (swim speed, direction of travel) and details of the animals' calls with MFAS activity nearby in space and time (e.g., call rates, types of calls, differences in call characteristics regarding MFAS activity).

2012

The Navy initiated a more intensive *pre* SCC field monitoring effort in 2012 than was undertaken in prior years. Surveys utilized both a 24 ft. (7.3 m) RHIB and, for the first time, a dedicated U.S. Navy vessel, the 225 ft. (67 m) ocean tug U.S. Navy Ship *Sioux* (see HDR, Inc. 2012a and Baird et al. 2012a, respectively, in Department of the Navy 2012). The survey was designed as a non-random, non-systematic survey designed to optimize encounter rates for the purpose of visual validation of acoustic detections and satellite tagging of species for which population size, habitat use, and movement pattern data are lacking and which may be exposed to U.S. Navy training. There were 161 sightings from the *Sioux* and 13 from the RHIB representing eight confirmed species including 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 (Table 3.3-3), including the first visual confirmation of a Blainville's beaked whale acoustic detection at PMRF.

Table 3.3-3: M3R, Sioux, and RHIB Acoustic/Visual Detection

Date	Species	Acoustic detections visually verified by
1/11/2012	Spinner Dolphin	RHIB
1/13/2012	Spinner Dolphin	Sioux
1/14/2012	Pilot Whale	RHIB
1/14/2012	Rough-toothed Dolphin	RHIB + *Sioux*
1/15/2012	Sperm Whale	Sioux
1/19/2012	Bottlenose Dolphin	RHIB + *Sioux*
1/19/2012	Blainville's Beaked Whale	RHIB + *Sioux*

Note: M3R, marine mammal monitoring on Navy ranges; RHIB = rigid-hulled inflatable boat

Since the *Sioux* is a large vessel and all crew remained aboard for the entire survey, the ship was able to perform longer observation days and cover more trackline. For example, during the 9 survey days, the Sioux averaged 10.6 hr/day and 147 km/day for 13.8 km on-effort trackline per hour. In contrast, in 7 days the RHIB averaged 6 hr/day and 93 km/day for 15.4 km on-effort trackline covered per hour. However, three odontocetes were tagged from the RHIB—two short-finned pilot whales and one rough-toothed dolphin—were tagged with satellite transmitters that transmitted locations for 11.7–73.2 days (see HDR, Inc. 2012 and Baird et al. 2012a in Department of the Navy 2012).

In addition to the *before* effort described above, acoustic recordings from the range phones, aerial surveys, and MMO embarked on Navy surface ships occurred *during* SCC. These will be analyzed in combination with the track data from animals tagged during the *before* surveys.

Analysis of prior data: In 2012, the case study methods of analysis using the instrumented range data were employed on the full February 2011 SCC.

Beaked whales: SPLs were estimated for beaked whale groups exposed to MFAS activity during the February 2011 SCC. Beaked whales (family Ziphiidae) and AN/SQS-53C MFAS activity were automatically detected post-event in recorded acoustic data. Manual validation of the detections was performed to ensure they fit known characteristics of beaked whale (foraging echolocation clicks, inter-click-intervals, and dive vocal periods) and that they coincide with MFAS activity. The whales were localized within a maximum 6 km detection radius from the hydrophone they were detected on. Estimates of the SPLs the beaked whale groups received from MFAS activity were calculated utilizing the U.S. Navy's standard personal computer interactive multi-sensor analysis training (PCIMAT).

Ten beaked whale dives were found to occur during MFAS activity at distances from potentially as close as 12.4 km to over 57 km with estimated exposure levels varying from 81 to 139 dB re 1 µPa (mean 115 dB, SD 9.5 dB) while the animals were at depth foraging. SPL estimates are also provided for these dives to represent the SPLs the animals would be exposed to when near the surface due to ducted propagation typically present in the area. The estimated SPLs for animals near the surface in the ducted propagation region were an average of 34.4 dB higher than those at depth and vary from 139 to 161 dB re 1 µPa (mean 150 dB, SD 5.7 dB). The click characteristics suggest that the beaked whales detected in the recordings are likely Blainville's beaked whales.

Humpback Whales: Sightings documented during SCC by MMO aboard a U.S. Navy surface ship and an aerial survey aircraft, MFAS use and acoustic detections were layered in order to estimate received sound pressure levels on exposed animals. The acoustic exposure is estimated as the SPLs in dB root mean square (rms) re 1 µPa rms. This analysis considers MFAS only from the AN/SQS-53C sonar system, at an assumed 235 dB re 1 µPa source level. The U.S. Navy standard PCIMAT acoustic propagation model was utilized to estimate the exposure levels on animals at a distance based upon the visual sighting and a presumed depth. All visual sightings were evaluated for presence of MFAS transmissions within a time window criteria (+/- 2 minute maximum utilized) in order to bound the animal location uncertainty at the time of exposure.

Estimated SPLs were obtained for a total of 16 sightings/re-sightings: seven shipboard sightings; three shipboard re-sightings; and six aerial sightings. The estimated SPLs vary from 136 dB re 1 µPa to a maximum of 196.9 dB re 1 µPa. This maximum value is for a worst case assumption for the animal being in closer proximity to the MFAS ship at the time of MFAS transmission, which was 33 seconds prior to the sighting. The estimated minimum SPL for this sighting is 183.6 dB re 1 µPa, which assumes the animal had been the maximum range modeled from the ship when the MFAS was transmitted. This highlights the need to consider the details of each sighting event, especially for short ranges with higher SPLs involved.

One can potentially obtain animal movement information by combining analysis from re-sightings or focal follows, of which one shipboard instance existed relative to MFAS activity during this training event. Data from this re-sighting instance indicates a group of humpback whales was moving at high speed towards the oncoming MFAS transmitting ship for a period of over 4 minutes.

3.4 PASSIVE ACOUSTIC MONITORING

The monitoring requirement for PAM in the HRC was satisfied by the use of a variety of methodologies. One is the use of an instrumented range at PMRF, described above in Section 3.3. The remaining methodologies are described below and may be broadly separated into two categories: (1) the deployment and resulting analyses (some of which are still in progress) of long-duration autonomous recorders, and (2) analyses performed on archival data sets collected through passive acoustic methodologies.

3.4.1 Long-Duration Autonomous Recorders

EARs were deployed in the vicinity of the islands of Niihau and Kaula Islet (Box 28), which lie to the west of the underwater range at PMRF. The EARs are long-duration autonomous recorders that are bottom-moored (Figure 3.4-1). Thus far there have been four sets of long-term deployments; analysis has been completed for one deployment, and is ongoing for the other three.

Figure 3.4-1: An EAR with the Components Labeled. The actual recording device is inside the tube surrounded by syntactic foam (see inset). This unit was deployed near Kaula Islet in June 2011.

The first pilot deployment was to two locations off Niihau in July 2010, one in deeper water (732 m) to its northwest adjacent to bathymetric features of relatively steep slopes, and the other in shallow waters (17 m) to the south. Both devices utilized an 80 kHz sampling rate with a 10 percent duty cycle. Based on both power and data storage capacity, both devices were expected to record for 6 months; however, both stopped recording after 3.2 months.

The "deep" EAR recordings revealed that beaked whales were the least-detected cetacean, and that pilot whales were the most detected, as measured by detections across all 30-second recording periods of the duty cycling. When considered by all recordings in a day, sperm whales detected on all days except one, and beaked whales were detected on 90 percent of the days. Odontocete species other than the above were also detected on all days. The majority of biosonar detections for all species occurred at night (low 77 percent for sperm whale, high 89 percent for beaked whale); this result is speculated to be dependent on diel cycles of foraging and prey availability. Risso's dolphins (*Grampus griseus*) were tentatively identified, but without further validation of the classifier or visual verification, the species identification may be questionable (see also Appendix A for all visual sightings of this species in HRC).

The "shallow" EAR recorded dolphin whistles and clicks on 32 percent of the days. Most of the whistle events occurred in the morning hours between 6:00 a.m. and 9:00 a.m. Hawaii-Aleutian Standard Time. Sounds presumed to be MFAS were detected on 5 days in total across the deployment.

This pilot deployment in shallow waters informed the decision to place future devices exclusively in relatively deep waters (i.e., >700m) for the subsequent cycles of deployments. Thus the second deployment was of 4 EARs in June and July 2011, one in the same location as the original "deep" EAR to the northwest of Niihau, two additional EARs, one each off the southwest and northeast tips of the island, as well as one to the east of Kaula islet, which lies approximately 37 km to the southwest of Niihau. All four locations may be considered to be in waters relatively adjacent to the instrumented underwater ranges of PMRF, a water area with a relatively frequent occurrence of Navy exercises. Deployment depths ranged between 526 and 737 m. The sampling rate was retained at the device maximum of 80 kHz. The duty cycle remained at 10 percent (30 seconds/5 minutes) for the three EARs at Niihau. The EAR at Kaula was set to a longer duty cycling of 5 percent (30 seconds/10 minutes) as a test to determine if this setting affected total recording life. After retrieval (January 2012 for Niihau devices, April 2012 for Kaula device), it was revealed that the Niihau EARs recorded for ~3.2 months, whereas the Kaula EAR recorded for 6.0 months. All future deployments of the EARs utilized a duty cycling of 5 percent.

There were two subsequent long-term EAR re-deployments at these same locations. Thus the next deployment, the third overall, was January–July 2012 for Niihau and April–October 2012 for Kaula. Unfortunately, the Niihau EARs still recorded only between 3.1 and 3.3 months, rather than the expected 6 months, and the Kaula EAR had a malfunction such that it stopped recording at 3 weeks. For the fourth deployment, the HRC monitoring plan had more flexibility in effort-based metrics related to acoustic methodologies. Therefore, given the difficulties in achieving a full recording period during multiple long-term deployments, it was decided to only redeploy the three devices at Niihau, such that funding could be allocated to other passive acoustic methodologies. This fourth and final deployment of three devices at Niihau began on July 2012 and they were retrieved in March 2013. Analysis across these three final deployments (between June 2011 and February 2013) is currently in progress and is planned to include coordinated analysis of marine mammal presence across the entire period.

The 2009–2012 period using this methodology and device will inform future application of acoustically-based methodologies for monitoring in HRC. The approach of a paradigm based fundamentally on effort-based requirements in the monitoring plans facilitated retrospective analyses after the fact of data collection for many monitoring methodologies, and deployment of long-term passive acoustic devices was not an exception. For example, once questions were posed after the deployment cycles of acoustic devices had begun, some types of study questions were retrospectively found to be inaccessible by any analysis of the collected data. Also, conclusions given by the analyses that were conducted were found to vary with regard to their perceived importance to progress in answering questions relevant to issues of the impacts of

Navy training. This was a consequence less of the acoustic analyst and more of the fact that the monitoring plan did not directly drive the contracting process to define explicit details of how an analysis deliverable would be evaluated with respect to study questions.

During 2009–2012, the monitoring plans were drafted such that although five study questions were defined, the default evaluation of the program, and therefore a primary motivator of its execution, was through predetermined numerical metrics of effort expended. In the future, monitoring will be planned, performed and evaluated based on the ability to provide progress on scientific questions relevant to monitoring issues without reference to specified metrics of effort, and therefore will defined by the monitoring plan and in some cases manifested through the contracting process, and will likely inform choices related to: (1) device capabilities (e.g., sampling rate, depth rating, mooring depth, storage capacity); (2) device placement (e.g., a study of displacement of animals away from a training range would require different device placement as compared to presence/absence of species on that range, or a study of deep waters would require devices capable of being placed in those waters); (3) device settings (e.g., duty cycle choices may facilitate or preclude the study of certain species or temporal call patterns); (4) whether or not to use autonomous moored recording devices (e.g., if species of interest cannot be reliably identified, funding might be redirected to development of species classifier algorithms and/or the use of vessel surveys to collect a larger library of visually verified acoustic samples).

As a hypothetical example, if the study question driving the deployment of acoustic recording devices was determining if beaked whale foraging dives were interrupted by MFAS, choices might include:

1. Continuous recording over the shorter term of an exercise rather than duty cycling over a longer period
2. Sampling rate near 200 kHz to take advantage of recent developments in identifying beaked whales to species using high frequency spectral components above 50 kHz
3. Placement of recording devices where beaked whales have been known to be present (e.g., from previous moored devices, or recordings across an instrumented range), even if the depth of water required may drive device choice
4. Concentration of funding toward analysis effort to answer this question to the exclusion of other questions or species of less interest
5. Consider whether other passive acoustic methodologies (dipping hydrophone, towed array, glider, instrumented range; acoustic animal tags) might be better-suited than a bottom-moored device

Some of these choices may drive higher unit cost (e.g., per device, per unit time, per recording, per day) such that although "less" might be accomplished according to metrics of effort, the value in terms of progress in monitoring science might be greater. In other cases, the cost to fulfill these choices might be so high that other monitoring questions entirely (even those addressed by non-acoustic methods or at other range complexes) may compete for priority for the limited pool of available funding for monitoring. The end goal then would be that any compromises or choices of some monitoring methodologies to the exclusion of others will be driven by the likelihood and desirability of progress of specific monitoring questions.

3.4.2 ARCHIVAL DATA ANALYSIS

3.4.2.1 Archival Data Analysis – HARP and Boat-Based Hydrophone

Marine mammal sounds were analyzed from recordings made in HRC during Fiscal Year (FY) 2009–2010 from two platforms: (1) a boat-based hydrophone deployed during small boat visual surveys, and (2) an autonomous bottom-moored High Frequency Acoustic Recording Package (HARP). The boat-based recordings included four encounters of pygmy killer whales (*Feresa attenuata*), three of melon-headed whales (*Peponocephala electra*), and one encounter each of Risso's dolphins and rough-toothed dolphins.

Echolocation click parameters including peak frequencies were made for recordings that could be verified to species either visually or by satellite tag. False killer whales and short-finned pilot whales had relatively low peak frequencies (15–21 kHz). Pygmy killer whales displayed a bimodal distribution of peak frequencies (35–50 Hz and 75–100 kHz). Melon-headed whales had a peak frequency of 31–35 kHz. Risso's dolphin had a notched spectrum with peaks at 24.5, 26.7, 34.6, and 40.3 kHz. Two unknown but apparently distinct click types found in the HARP recordings were described. One had a minimum frequency at ~70 kHz and extended beyond the 100 kHz limit of the recording. Due to the hint of an FM sweep within the recorded band, it was hypothesized to be a beaked whale species of unknown origin. The other was a low frequency click with a banded spectrum with peaks at 12.2, 16.4, and 23.8 kHz, a banding pattern similar to that described for short-finned pilot whales at 12.6, 18.8, and 28.2 kHz.

HARP recordings off the west coast of Hawaii Island in February–March 2009 were manually examined. An existing automatic classifier for beaked whale clicks was also manually verified for missed detections and false positives. Recorded echolocation click types included the Cross-seamount beaked whale clicks, sperm whales clicks, unidentified clicks including high frequency ones, low frequency banded clicks, and other unidentified echolocation clicks. Odontocetes were detected on every day for ~65 percent of the total hours recorded, and showed a strong diel association with night-time hours. Beaked whales were detected on 41 percent of the recorded days over ~4 percent of the total hours. Anthropogenic sounds such as ship engines and echosounders (28.8 kHz, 30 kHz, and 50 kHz) were also recorded and their diel patterns were reported.

Overall, the relevance of this archival analysis to Navy monitoring questions may be evaluated as high because of the validation of species identification progressed the state of knowledge of the characteristics of what the phonations of various species sound like in HRC. Some species produce sounds that are different and distinct in different waters even of the same ocean basin, and therefore it is a possibility that species well-measured with visual validations in other Pacific waters, such as the Eastern Tropical Pacific (ETP), may not necessarily be correctly identifiable when recorded in the waters of HRC. Also, continued detection of the so-called Cross-seamount beaked whale is an intriguing question that may lead to changing the notion of which beaked whale species are present in this range complex.

3.4.2.2 Archival Data Analysis – EARs

Archived acoustic data were analyzed from six passive acoustic monitoring devices (EARs) deployed in 2009 and 2010 by HIMB. The EARs were deployed at depths ranging from 104 to 672 m—two off the west coast of Kauai, and four off the western, eastern, and southern shores of Oahu. Date ranges corresponding to nearby Navy training events were chosen for each device, and ranged from between 2 and 13 days per device. All devices had a duty cycle of recording 30 seconds on every 5 minutes. The sampling rate of the Oahu devices was 64 kHz and that of the Kauai devices was 80 kHz.

Eight marine mammal species were acoustically identified from these data (Au et al. 2011): spinner dolphins, pan-tropical spotted dolphins, rough-toothed dolphins, striped dolphins, short-finned pilot whales, false killer whales, bottlenose dolphins, and humpback whales. Within the constraints of the acoustic files generated by the duty cycling, time periods for detecting dolphin whistles (including species categorization using Real-time Odontocete Call Classification Algorithm (ROCCA) based on algorithms from animals recorded predominantly in the ETP), biosonar (clicks), anthropogenic sonar, and boat noise were described for each day. Changes in noise spectrum across bins representing divisions of the time of day were given for each device. Sample spectrograms of boat noise, anthropogenic sonar, and dolphin whistles were also provided. However, the advancement of new knowledge relevant to Navy questions was limited. The species detected did not represent fundamentally new information, and the methodology was not amenable to addressing patterns of presence and abundance. Also, an analysis of associations between detections of MFAS and animals was not made, due to a contracting misunderstanding. Because only the days of the actual exercise were used for the analysis, it was not possible to measure changes in acoustic detections of animals in the periods before, during, or after Navy training events.

3.5 TAGGING

Tagging is an element of the monitoring program in HRC that provides direct information on animal movements and, in some cases, dive patterns. Tags have been deployed on pinnipeds (Hawaiian monk seals) and cetaceans. The focus of cetacean tagging so far has been odontocetes. This is for two reasons: (1) information is lacking on many odontocete species in HRC and they are a present group of species in locations where the Navy trains, and (2) the only mysticetes that have been reliably encountered are humpback whales and other studies have recorded their general movements through tagging. In the future, tagging that is more focused on behavior in the presence of Navy vessels could be attempted, but is not planned in the immediate future. Additionally, tagging of sea turtles could be a possible future monitoring activity, if there were a suitable monitoring question that could be addressed through satellite tags on sea turtles. There is a section below for each of the two groups of marine mammals that have been tagged.

3.5.1 PINNIPED TAGGING

Hawaiian monk seals were the first marine mammal tagged for TAP, Phase 1 monitoring in the HRC. There is a small population (less than 160 animals) in the MHI (Baker et al. 2011, Lowry et al. 2011), but they are considered to be a crucial population to this critically endangered species. The Hawaiian Monk Seal Research Program at NMFS, led by Dr. Charles Littnan, deployed the tags; Dr. Littnan worked with a Duke University graduate student (Kenady Wilson), who performed the analysis of the movements and derived home ranges of the monk seals that were tagged. The tags were based on cell phone technology and were affixed to seals starting in February 2010. During HRC monitoring year two, between 10 February and 29 June 2010, 11 tags were deployed: three tags on Oahu, four tags on Kauai, and four tags on Molokai. The original intention was to deploy 15 tags with Navy monitoring funding. That goal was not met in the first year of the project because seals meeting the right criteria (e.g., correct age class, stage of molt) were not available during scheduled survey periods. In addition, a bad batch of glue led to the first four tags coming off the animals prematurely. During HRC monitoring year three, between 21 January and 15 July 2011, 10 tags were deployed: two tags on Oahu, three tags on Kauai, five tags on Molokai. Ultimately, of the 21 tags deployed, data could be retrieved and analyzed from 12 tags.

A great deal of new insight into monk seal movements, home ranges, and activity budgets was gained from the body of data collected by these cell phone tags. When considered collectively, the data indicate that seals spent, on average, 4.4 hours at the water surface, 11.6 hours diving, and 7.0 hours hauled-out on land in a single day. The seals go to sea to forage and the average foraging trips was 29.7 km in distance and was executed in 0.79 day (almost 19 hours). With one exception, none of the foraging trips was longer than 300 km and most trips were less than 50 km. There was quite a bit of variability in trip distance and duration both in and between seals. Two seals made at least one long pelagic foraging trip during the deployment period. An adult male tagged on Oahu traveled over 3,000 km on one trip which lasted 36 days (Figure 3.5-1). A sub-adult female tagged on Kauai traveled 300 km on one trip that lasted almost 4 days.

Of the 12 tags deployed, two were attached to females. The data showed that the two females dove to similar mean depths and durations to male seals, but there was less variation in both the depth and durations of their dives. Additionally, the maximum depths and durations reached by the females were shallower and shorter than the males. For all of the seals, mean dive depth was 27.03 m with a maximum of 529 m and a median depth of 14.4 m. The average dive duration of dives was 5.01 minutes with a median of 5.07 minutes, and 28 percent of the time between dives was spent at the surface.

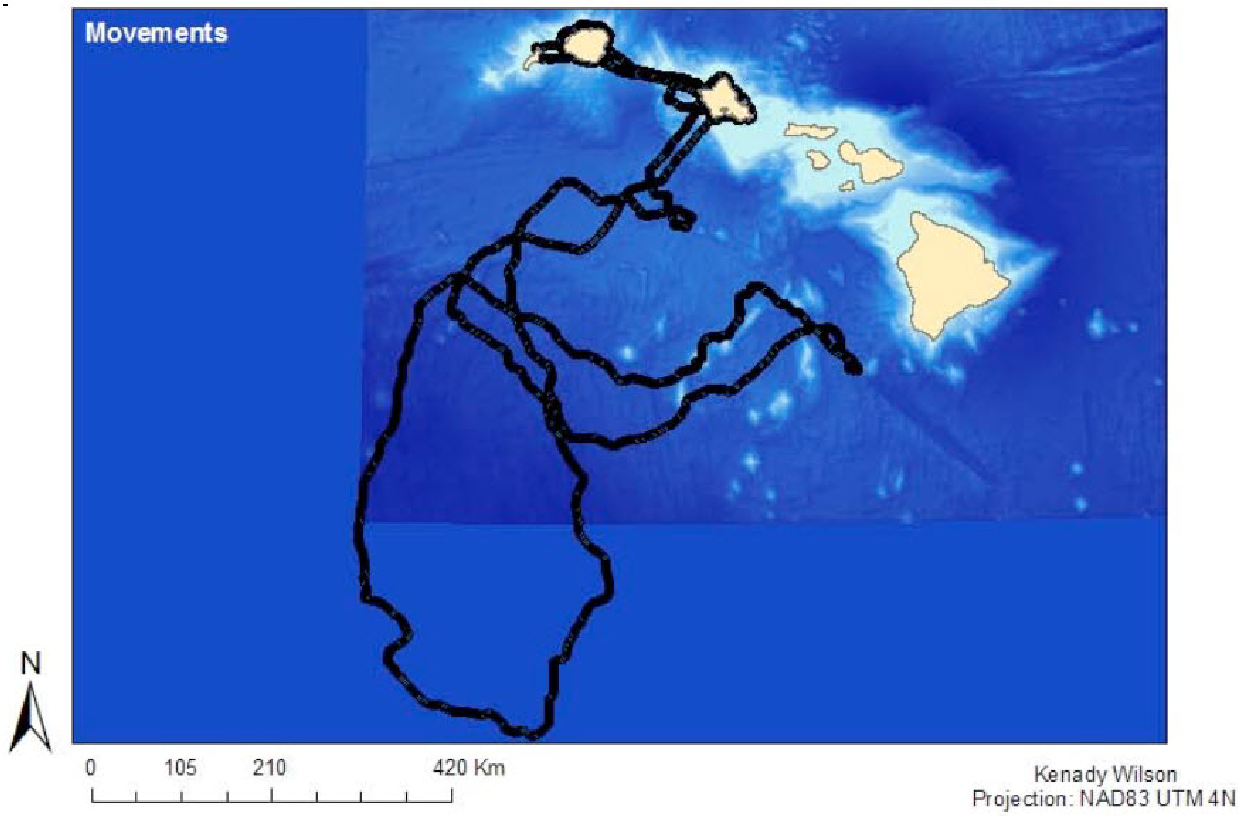


Figure 3.5-1: The Trackline of a Tagged Hawaiian Monk Seal Including an Unusually Long Pelagic Trackline (from Littnan and Wilson 2011)

Most of the seals remained within the 600 m depth contour near the MHI, but there was high variability in the space utilized by individuals. Fifty-four percent of the seals made regular trips between two or more of the islands, while the remainder showed fidelity to one island. The Hawaiian Monk Seal Research Program team (including Duke University) calculated fixed kernel density home ranges and core area estimates for the 11 monk seals for which there was enough data. Most seals had core areas on one island regardless of their inter-island travels; however, two animals that spent considerable time on multiple islands had segmented core areas that spanned multiple islands. Core area sizes were similar between seals, while home range sizes were more variable. During foraging trips, four of 11 tagged seals for which data could be retrieved crossed the shallow water range at PMRF between Kauai and Niihau.

The evidence supplied by these tags provides information on several important things with respect to Hawaiian monk seals and their presence in waters used by the Navy for training: (1) although most seals remain in relatively shallow water (less than 600 m) close to the MHI, on rare occasions some seals make longer pelagic foraging trips that could place them in locations where the Navy trains; (2) some seals move across the SWTR at PMRF with regularity and may be in contact with and familiar with human activity in that area regularly; (3) some monk seals have home ranges near PMRF and persist in using an area for foraging that has been a Navy training area for decades; and (4) based on the activity budgets obtained by the tags, the Navy now has, for modeling and estimation purposes, a dataset to provide the percentage of time seals spend in the water and what the likely proportion is of a monk seal being in the water at any given time.

3.5.2 Odontocete Tagging

Tagging cetaceans commenced during February 2011 in the third year of the TAP, Phase 1 monitoring in HRC. The arrangement for achieving tagging goals had to be flexible, because placing tags on cetaceans is an unpredictable endeavor. Many factors worked against the tagging team succeeding. The factors including finding target species, encountering the correct age and size class of individuals suitable for tagging, being able to get close enough and in the right position to place a tag, and environmental conditions being conducive to tagging effectively. In Hawaii, the last factor is particularly salient. The right species and individuals may be present to tag, but environmental conditions may prevent a tagging team from getting to the species or even operating safely.

Four species have been tagged for HRC marine species monitoring: short-finned pilot whales (*Globicephala macrorhynchus*, five tags), rough-toothed dolphins (four tags), common bottlenose dolphin (one tag), and false killer whales (three tags). A section summarizing the results for each species follows below. The tagging effort reported on in this review has taken place near PMRF. In December 2012, some tagging took place off of Lanai, but data collection had not yet finished at the time of writing. The summary provided in this section will specifically focus on tags funded by COMPACFLT for HRC monitoring, but results from tags that have been deployed contemporarily with monitoring-dedicated tags will be included when they provide additional insight.

CRC, as a sub-contractor to HDR, Inc. has deployed all of the tags on cetaceans in HRC during TAP, Phase 1 monitoring so far. The suite of tagging projects they have been involved in has allowed HRC monitoring goals to be met while synergizing well with other tagging projects. Although the tagging team has participated in efforts that were focused on training events, such as an SCC, not all tags have been able to be deployed during those efforts. Since CRC also receives funding for tagging projects funded by the ONR, LMR, and NMFS, they have been able to deploy tags in HRC on target species during projects funded by other entities. The results are particularly synergistic because all parties benefit from the knowledge obtained from all the tags that were deployed. This joining of purposes for tagging has been an efficient and effective use of funds and manpower.

Short-finned Pilot Whales

In February 2011, during SCC, three adult male short-finned pilot whales were tagged off the north shore of Kauai, just east of PMRF (Box 35). Two of the tags transmitted data on location only while the third tag transmitted location and dive depth information. CRC had tagged six pilot whales off Oahu in October 2010. All of the pilot tags showed considerable variation in movement patterns and habitat use. Some tagged animals remained close to the area of tagging, suggesting residency, and others moved over very wide ranges, using a broad range of depths. The combination of these nine tags significantly expanded the knowledge of pilot whale spatial use and range patterns in the western MHI.

The tags placed on the pilot whales near Kauai were deployed over 2 days during two different encounters and transmitted from 30.9 to 37.1 days. Although two of the animals were tagged within one km of each other, all three tagged whales appeared to be from different social units, based on movement patterns. Based on photo-identification, one pilot whale sub-group had no previous sightings. The majority of members (16 of 17 individuals) of another sub-group had been sighted previously off the island of Oahu. All three groups of pilot whales appeared to be utilizing habitat within and adjacent to PMRF, within the monitoring period although each showed differing movement patterns. One tagged pilot whale spent some time off of the west side of Oahu in addition to Kauai.

The six tags deployed near Oahu were deployed on three different days. In the first group of pilot whales in which three tags were deployed, almost half of the distinctive individuals (nine of 21) had been previously photo-identified off the island of Lanai. Individuals from this group remained strongly associated with Oahu and the four-island area (the islands of Molokai, Maui, Lanai, and Kahoolawe) for the entire duration of tag transmissions (covering a 223-day span for one individual). Most of the time was spent off the leeward (west) shores of Lanai and the south and west shores of Oahu. Tagged individuals from this group were strongly associated with the slope, with most locations occurring in depths of less than 3,000 m. The relatively localized movements, strong association with the slope, and large proportion of individuals that had been previously photo-identified suggest this is a resident group to the Oahu/four-islands area.

By contrast, three other pilot whales tagged off Oahu in October 2010 ranged widely among the western MHI, including around Kauai near PMRF, and almost as far as Nihoa in the NWHI. These three whales also ranged far offshore. While remaining within the HRC, one individual crossed three management boundaries: the long-line exclusion zone around the MHI, the Papahanaumokuakea Marine National Monument Boundary, and the U.S. Exclusive Economic Zone boundary surrounding Hawaii. This was the first direct evidence that any species of odontocetes from the MHI may utilize either waters within the Marine National Monument or international waters.

In January 2012, CRC deployed two more tags on short-finned pilot whales during a major monitoring effort prior to SCC (Box 46). One of the pilot whales was an adult male and the other was an adult of undetermined sex. The tags collected location information only, and they broadcasted for 11.7 and 73.2 days. Although tagged in the same large aggregation of whales, the two pilot whales showed movements that suggested they were from different social groups. Social network analysis from photo-identification supports this conclusion. Comparison of photos of short-finned pilot whales from the three encounters CRC had during the January effort resulted in identifications of 43 individuals, all of which had previously been documented in the western MHI. The two individuals who had been tagged had been identified as early as 2003 off either Kauai or Oahu. As with the other pilot whales, there was a difference in movement patterns between the two tagged individuals. During the 11.7-day track, the individual circumnavigated Kauai, remaining a median distance from land of 12.0 km (maximum = 35.8 km). During the 73.2-day track, this individual circumnavigated both Kauai and Niihau and also moved to waters off west Oahu. While remaining a median distance from land of 15.9 km, the maximum distance offshore documented was 122.2 km, with the tagged individual crossing into areas where long-line fishing may be undertaken.

The evidence supplied by the tags described above convey several important things for pilot whales and their presence in waters used by the Navy for training: (1) some groups of pilot whales may be resident to a limited range and may be in contact with and familiar with human activity in that area regularly; (2) there is movement of individuals across relatively large distances in the MHI island chain, thus suggesting that pilot whales that are observed distant from Navy training may still have some contact with the training over time; (3) the movement of tagged animals transiting and concentrating on the area north of the channel between Niihau and Kauai (where PMRF is located) suggests this area may have ecological importance to this species; and (4) pilot whales persist in using locations where the Navy has been training for many decades.

Rough-toothed Dolphins

During July and August 2011, CRC tagged three rough-toothed dolphins on PMRF prior to a SCC (Box 41). Two of the dolphins were adult males and one was an adult of unknown sex. These tags were the first remote deployments of satellite tags on rough-toothed dolphins anywhere in the world (see Figure 3.2-11 in Section 3.2.2). The tags broadcasted for 7.6 to 18.5 days and they collected location information only. Two of the three tagged rough-toothed dolphins had been photo-identified off Kauai in 2007 and 2008. Although the third individual had not been documented previously, it was associated with others that had been previously documented off Kauai. This third individual was subsequently re-sighted off Kauai in January 2012. All three rough-toothed dolphins remained strongly associated with the islands of Kauai and Niihau, with movements centered on the PMRF range. Movement patterns suggest that the tagged individuals were from two different social groups.

During the January 2012 tagging effort, CRC deployed a tag on a rough-toothed dolphin prior to SCC (Box 46). The individual was an adult of undetermined sex that had been previously documented off Kauai in 2005 and 2011, and off the island of Hawaii in 2006. This individual is one of only two individual rough-toothed dolphins known to have made large-scale movements within the MHI (Baird et al. 2008). Social network analysis shows that this individual is part of the main social network of rough-toothed dolphins that has been documented off the islands of Kauai and Niihau, which includes the three rough-toothed dolphins satellite tagged in 2011 (Baird et al. 2012). The tag on the rough-toothed dolphin collected only location data for a 27.5-day period, providing the most extensive track available for a satellite-tagged rough-toothed dolphin in Hawaii (Baird et al. 2012). This individual ranged more broadly than previous tagged rough-toothed dolphins, circumnavigating Kauai and covering a broad range of area off Niihau.

The data from the four tags described above and the photo catalogs for the species in the Hawaiian Islands convey several important things for rough-toothed dolphins and their presence in waters used by the Navy for training: (1) around the Hawaiian Islands, small odontocetes are expected to be resident to a specific island or group of islands (that may be true for Kauai/Niihau, but there may be several social groups of rough-toothed dolphins that use the area near PMRF regularly); (2) although it may be rare, there is movement of individuals across large distances in the MHI island chain, thus suggesting that rough-toothed dolphins that are observed distant from Navy training may still have some contact with the training over time; (3) with the movement of tagged animals transiting and concentrating on PMRF, this area may have ecological importance to this species; and (4) rough-toothed dolphins are abundant and active in an area where the Navy has been training for many decades.

Bottlenose Dolphin

During the same tagging effort that tagged the three rough-toothed dolphin in July and August 2011 (Box 41), CRC tagged an adult male bottlenose dolphin (Figure 3.5-2). This tagging was the first of this species remotely tagged with a satellite tag in Hawaiian waters. The tag broadcasted for 34 days. While the individual's identification did not match any known individuals in CRC's catalog, of the 45 photo-identified individuals from this encounter, 15 individuals had been previously documented off of Kauai or Niihau in 2003, 2004, or 2005. This evidence suggests the tagged individual is part of the resident population from those islands (Baird et al. 2009). This individual remained associated with the island of Kauai for the duration of the tag activity. The dolphin remained in relatively shallow water during the tag deployment, using waters with an average depth of 82 m and remaining an average of 2.24 km from shore.

Figure 3.5-2: A LIMPET Tag on the Dorsal Fin of the Bottlenose Dolphin that Was Tagged at PMRF in August 2011. This individual has a distinctive trailing edge on its fin. It should be easy to identify when resighted in future years. The green dots on the base of the dorsal fin are lasers from a photogrammetry camera system. Photo by Jessica Aschettino under NMFS permit #15330.

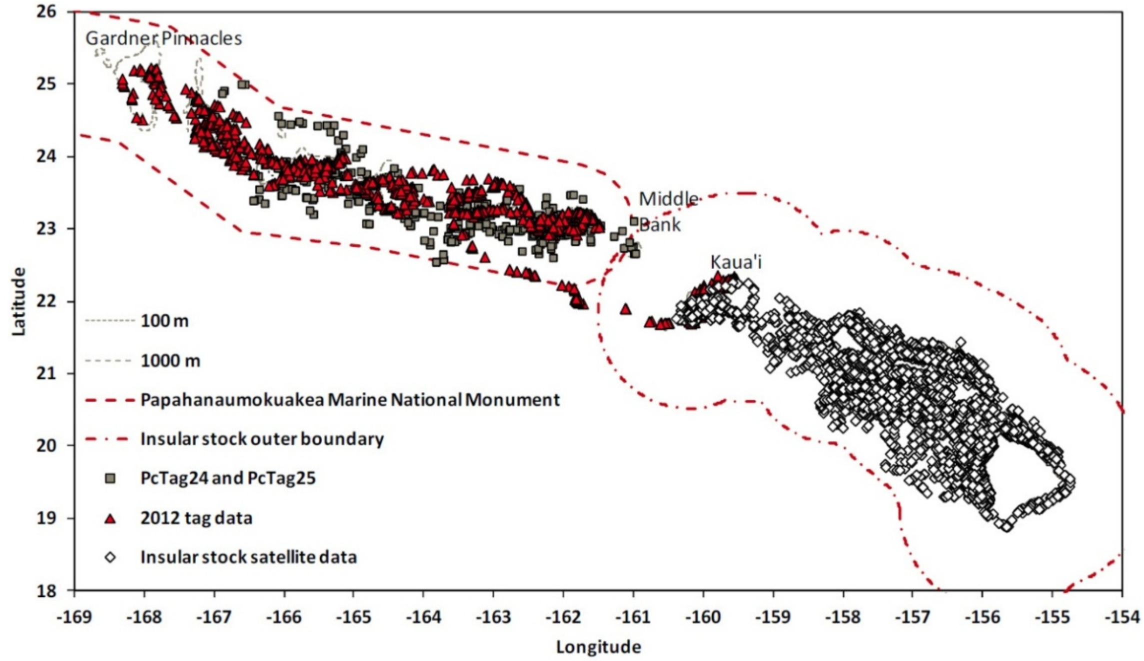
The information from the bottlenose dolphin tag and photo-identification catalog indicates that, in addition to rough-toothed dolphins, there is a resident or regularly present group of bottlenose dolphins in the vicinity of west Kauai, Niihau, and PMRF. Like other populations of odontocetes, such as short-finned pilot whales and rough-toothed dolphins, this population is likely experienced with Navy activities and persists in an area where Navy activity has occurred for many decades.

False Killer Whale

The Navy has preliminary information for a tagging effort from June and August 2012 that has not been formally reported yet (Box 54). Three tags of critical importance were deployed on three false killer whales during two encounters on subsequent days on PMRF in June. The tags collected location and one tag collected diving information as well. The tags transmitted for 16, 22, and 42 days. After tagging, the whales stayed in the area of PMRF, Niihau, and the north shore of Kauai for less than 2 days and then swam to the area around Nihoa, Necker, French Frigate Shoals, and Gardner Pinnacles in the NWHI.

None of the photo-identifications gathered during the encounters matched known false killer whales from other populations. Most significantly, there were no matches to the MHI insular population, for which there is an extensive catalog. The MHI insular population was listed as endangered under the ESA on 28 November 2012. The lack of matches with the MHI insular population catalog suggests that the group was probably from a pelagic population or the NWHI insular population. The movement patterns strongly suggest that the group is likely to be from the NWHI insular population or pelagic population.

The preliminary information from the tags and photo catalogs described above convey several important things for false killer whales and their presence near PMRF: (1) there is evidence that some populations of odontocetes that move through the NWHI also visit the area around PMRF, albeit infrequently; (2) the endangered population of MHI insular false killer whales only receives a portion of the take allocated to this species in the Navy's permit as individuals from at least two populations occur in the area of PMRF where the Navy trains regularly; and (3) PMRF appears to be in a small corner that may be at the maximum extent of two populations of false killer whales (Figure 3.5-3) (i.e., the southwest edge of the NWHI population and the northeast edge of the MHI insular population); therefore, it is in question how much false killer whales utilize the habitat around Kauai and Niihau in proportion to the overall span of their ranges.



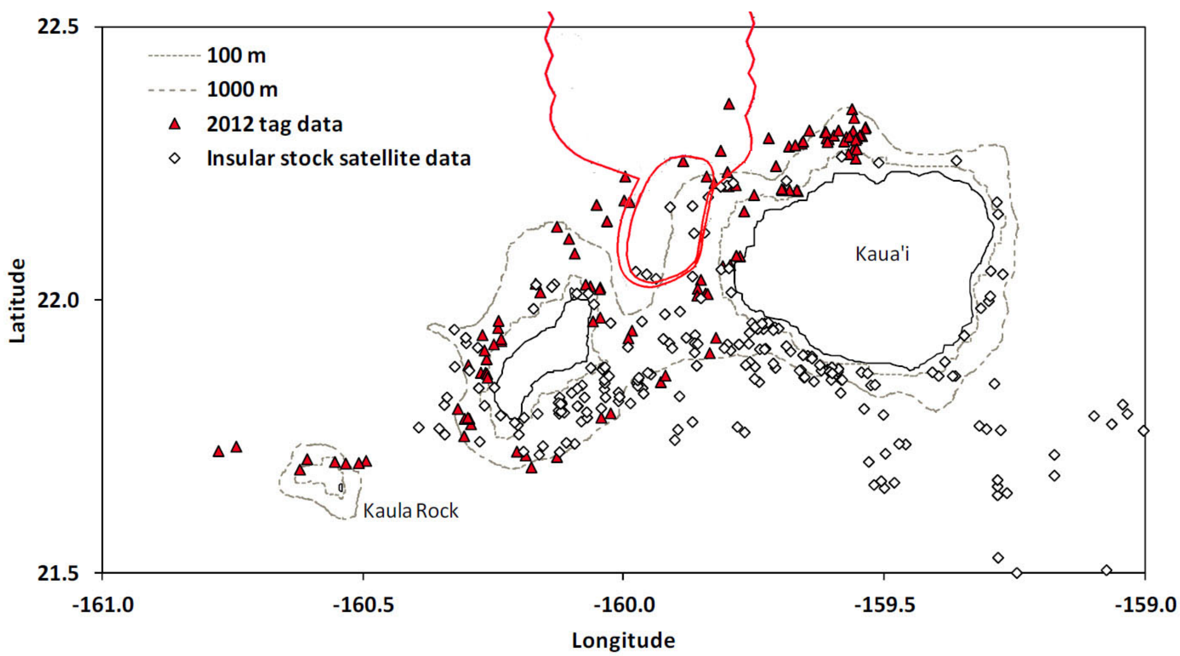


Figure 3.5-3: (Adapted from Baird 2012) Top: Satellite Tag Positions for Tags Placed on False Killer Whales Across the MHI and NWHI. White diamonds: individuals known to be from the Hawaiian Insular population. Red triangles: false killer whales tagged in June 2012. Bottom: The Overlap of Satellite Tag Positions near PMRF. The boundary of PMRF underwater ranges is depicted by the red line.

3.6 LOOKOUT EFFECTIVENESS

3.6.1 EXPLOSIVES MONITORING

An LOE was developed specifically for explosives monitoring in the HRC with the goal of assessing the effectiveness of the lookouts (LOs) and mitigation and at the same time gathering marine mammal and sea turtle observations during UNDETs. For the purposes of this study, an "event" was a detonation, regardless of size. Sinking exercises (SINKEXs) are treated differently in that the entire exercise is considered an event even if there are multiple detonations.

3.6.1.1 UNDETs at Puuloa Training Range

MMO monitoring during UNDETs at Puuloa Training Range are conducted from a shipboard platform: a small RHIB less than 10 m long, provided and piloted by Mobile Diving Salvage Unit One. Two MMOs were on board, each equipped with a pair of 7x50 binoculars and watch. MMOs had access to very high frequency communications with the other boats. One MMO was the data recorder as well as a secondary observer, and was equipped with a clipboard with data entry sheets and a handheld chart-plotting marine global positioning system (GPS) unit. The MMOs were on effort throughout the duration of the day, from the time of the vessel leaving the dock, until its return. All sightings by MMOs and Navy LOs were recorded, as well as whether mitigation measures were followed.

UNDETs observed have ranged in size from 1 to 20 lbs, and all have been "positive control," meaning triggered using a remote firing device. The UNDET training requires Navy divers to be vigilant with a number of safety considerations, not only for the environment, but for the personnel on board and civilians in the vicinity. UNDET monitoring at Puuloa Training Range was carried out during six events in 2009, four events in 2010, and six in 2011 and 2012. Marine mammals-spinner dolphins and monk seals-have only been observed twice during two events (Boxes 15, 43, and 44; see Table 3.6-1). The spinner dolphins were observed in 2009 and the monk seal was sighted between the first and second detonations/events of the day. Although there was a small amount of fish kill from the first UNDET, the pod of 10–20 animals transited straight through the area, followed by the contracted vessel that was conducting monitoring in conjunction with the Navy. The 30-minute timer for the last detonation was commenced once the animals were outside the mitigation zone. The Hawaiian monk seal was first observed at the surface with a large fish in its mouth. It is unknown whether the fish was a casualty of the first detonation or just coincidence. After consuming the fish, the seal dove and was last observed 318 yards (291 m) from the detonation site heading NW, away from the detonation. After 40 minutes, the second and third detonations occurred. The monk seal, which had been individually identified from natural markings, has been observed in good health and acting normally on multiple occasions since the UNDET. Another group of spinner dolphins was observed after the UNDETs were completed in 2011 on the way back to the MDSU dock in Pearl Harbor.

Fish kill observed on the surface has been minimal. The divers prefer to use the same general area for their training, and the bottom is sandy. When the Navy has conducted observations on sequential days, the divers have commented that sand has refilled the crater created by the detonation on the previous day.

Table 3.6-1: Marine Species Observed at Puuloa during UNDET Monitoring

Species observed	2009	2010	2011	2012
Spinner dolphin*	X		X (returning to port)	
Hawaiian monk seal			X	
Green sea turtles	X	X	X	X
Fish kill	X			X

* Spinner dolphins observed outside of the UNDET range
Note: UNDET = underwater detonation

The UNDET participants know the mitigation requirements well and followed them as described in the MMPA permit and Hawaii Range Complex Environmental Impact Statement. All members of the crew that are not diving are monitoring for marine mammals and sea turtles, either at the UNDET location or while surveying in a circular pattern around the detonation site. Unlike the LOE study conducted aboard Navy surface ships conducting MFAS, this study was not conducted blind. The MMO notified the Navy crew as soon as a sea turtle or marine mammal was observed or vice versa if observed first by the Navy divers. Observations over the 22 monitored UNDETs demonstrated that the divers are following through on the mitigation measures as designated.

3.6.1.2 SINKEX

The purpose of a SINKEX is to train personnel and test weapons against a full-size ship. Each SINKEX uses an excess vessel hulk as a target that is eventually sunk during the course of the exercise. Any exercise that normally uses a surface target (e.g., gunnery exercise, missile exercise) can be a part of the SINKEX. The hulk ship is towed to a designated location where various platforms use multiple types of weapons to fire shots at the hulk. The purpose of monitoring during a SINKEX is to gather data towards answering monitoring questions 4 and 5 (see Section 1.3 and Department of the Navy 2008).

The only way to safely monitor a SINKEX and get close enough to the hulk to observe for marine mammals is from the air. P-3s are used for mitigation prior to firing weapons at the hulk; a helicopter is used to videotape the event. For the two monitored SINKEXs, the hulks utilized as targets were:

- 10 July 2010: Former USS New Orleans (LPH-11) helicopter landing platform amphibious assault ship
- 17 July 2010: Former USS Anchorage (LSD-36) dock landing ship

For both events, an MMO was assigned to each of a pair of Sikorsky S-61N helicopters operated by a private contractor, flying from Barking Sands PMRF airfield (Box 25). A pair of two helicopters rotated flight shifts to provide continuous coverage of the event. The helicopters transited to the exercise site, then began performing Extended Range Video System (ERVS) coverage while flying at a safe standoff distance and altitude. One MMO was equipped with a hand-held GPS device, and tracks from the flights were recorded, but not all portions of all flights were recorded due to limited battery life of the unit. Because the hulk was unanchored at the beginning of the exercise, it drifted in position during the course of the exercise. The two MMOs performed more than 27 hours of monitoring in total across both SINKEXs on 10 July and 17 July 2010.

No sightings of marine mammals or sea turtles were made by the MMOs, helicopter pilots and crew, or by the other subsurface, surface and aerial exercise participants. The events of these SINKEXs were therefore not ceased, delayed, or modified by marine mammal or sea turtle sightings, as would be required under mitigation guidelines.

This effort was valuable for the MMOs to observe a SINKEX comprised of multiple cooperating groups, as well as observing the discharge of different types of ordnance, including several missile types, guns, bombs, and torpedoes, as fired from surface ships, aircraft, and submarines (Figure 3.6-1). The Battle Damage Assessment (BDA) phase of the ERVS mission provided the MMOs with a clear view of the water within the mitigation area surrounding the hulk. Knowledge of the length of the hulk afforded a convenient reference with which to judge the mitigation area distances. Observational coverage during BDA was somewhat improved when two MMOs were aboard the same flight, since this format allowed one observer each to look out on both sides of the aircraft, scanning a view of the water towards, as well as away from, the hulk. However, even with a single MMO, all waters within the mitigation area eventually became visible even when viewing from a single side of the aircraft, due to the circular path around the hulk continuously affording a good view of the waters between the aircraft and the hulk, as well as immediately beyond the hulk.

Figure 3.6-1: The Explosion from a Torpedo Striking the Former USS Anchorage (LSD-36) During SINKEX Training. The bubble pathway of the torpedo can be seen as a white line in the water in the foreground of the picture.

Due to safety considerations of altitude and distance, the MMOs were not able to monitor the mitigation area effectively from the ERVS platform during the portions of the flight other than BDA (Figure 3.6-2 shows the view of the hulk from a safe viewing distance of 10,000 ft.). Also, because the ERVS mission was not intended to provide range clearance, the MMOs were unable to evaluate the primary range clearance and surveillance activities conducted by aircraft such as P3s. It is possible that MMO presence aboard these craft might provide information regarding the effectiveness of these measures. However, it is unlikely that MMOs aboard P3s would have as good an observational opportunity as an ERVS helicopter during BDA, due to the helicopters' particularly low altitude and groundspeed during BDA.

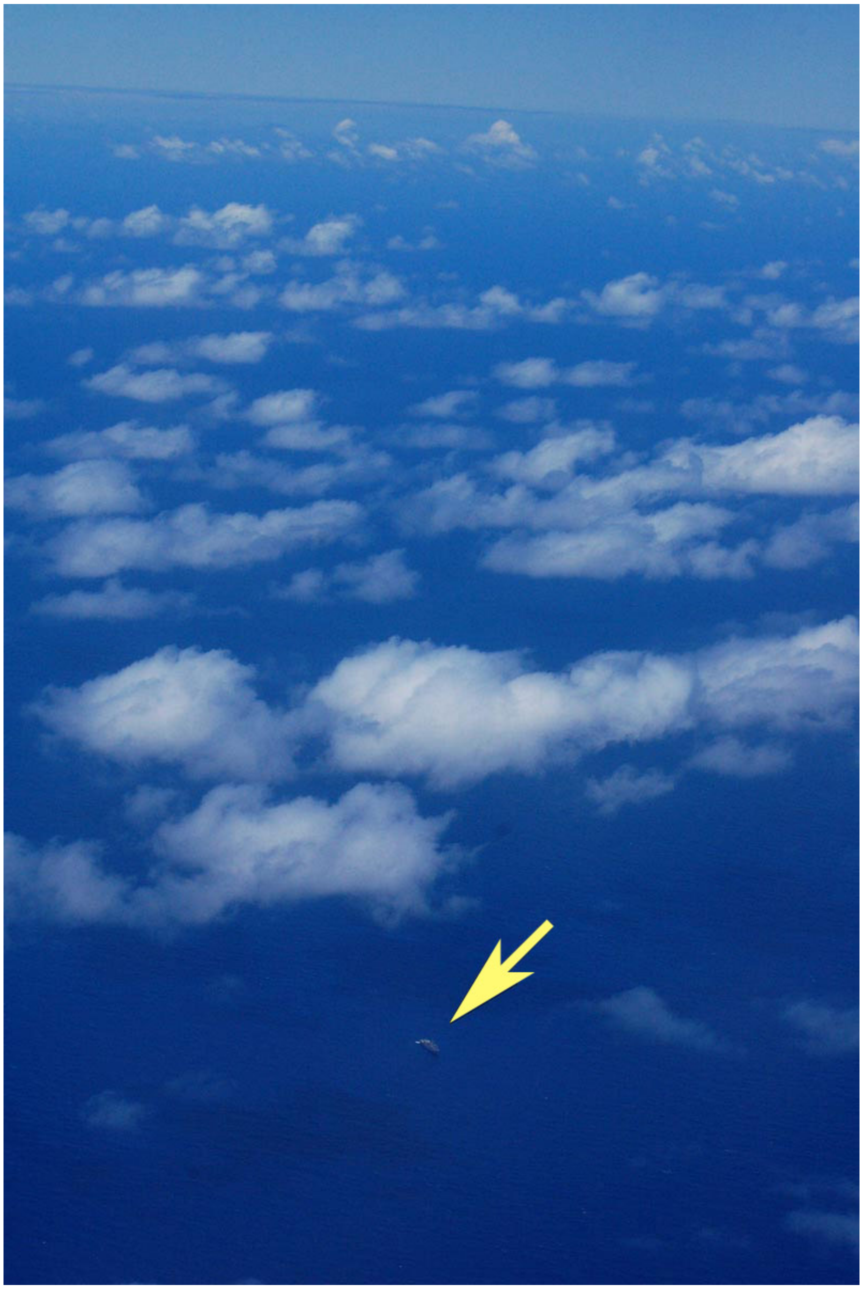


Figure 3.6-2: A View of the Hulk Ship Targeted During a SINKEX in July 2010. The view is from 10,000 feet on an ERVS platform, illustrating difficulty of seeing animals. The yellow arrow points to the hulk.

Given the limitations of monitoring during the SINKEX, additional monitoring has not been conducted on subsequent SINKEX.

3.6.2 MARINE MAMMAL OBSERVERS

The U.S. Navy undertakes monitoring of marine mammals during Navy training events and has mitigation procedures designed to minimize risk to these animals. One key component of this monitoring and mitigation is the shipboard LOs (also known as watchstanders), who are part of the standard operating procedure that ships use to detect objects (including marine mammals) within a specific area around the ship during events. The watchstanders are an element of monitoring requirements specified by NMFS in the MMPA LOAs. The goal is to detect marine mammals entering ranges of 200, 500, and 1,000 yards around the vessel, which correspond to distances at which various mitigation actions should be performed. In addition to the LOs, officers on the bridge search visually and sonar operators listen for vocalizations. All of these observers together are referred to as the observation team.

MMOs were embarked on Navy sonar equipped surface ships to evaluate watchstander effectiveness, and document compliance with proscribed mitigation for sonar and explosive use (e.g., gunnery exercises).

While initially focused on all Navy surface ship platforms, it quickly became apparent that sticking to a single ship type would be more conducive to across-range complex comparisons (e.g., same line of sight from the bridge). Therefore, attempts to always embark MMOs on Arleigh Burke class destroyers (DDG) were made.

Also, due to the relatively higher density of marine mammals and consequently the higher likelihood of marine mammal sightings, the SOCAL Range Complex was recognized as a key location in which to conduct MMO embarks. However, a number of logistic limitations have made scheduling effective MMO embarks from San Diego a challenge. Naval Base San Diego is a critical surface ship Fleet concentration area in the Pacific. While this provides a greater number of potential ship platforms, it also means a much higher maintenance, training, and deployment tempo. Furthermore, ship participation in MTEs within SOCAL often leads to strains on available spare berthing with the addition of exercise evaluators, trainers, and equipment support personnel who participate during these events. Therefore, the scheduling of several embarks each year in HRC continued through 2012, although it is possible that in future monitoring years, the majority of MMO embarks related to MFAS may shift toward SOCAL, with fewer embarks in HRC.

Eight MMO embarks were conducted in HRC between 2009 and 2012. Table 3.6-2 lists all embarks with notes on sightings, ship class (DDG, cruiser [CG], or frigate [FFG]), and whether or not components of layering monitoring methods (as described in the Training Event Case Study, Section 3.3) were utilized, specifically aerial orbital surveys that follow the Navy ship, or embarking on a ship conducting an exercise performed on the underwater instrumented range at PMRF.

Table 3.6-2: Marine Mammal Observers Embarks in the Hawaii Range Complex (2009–2012)

No.	Date	Platform	LOE study	Aerial follow of this ship?	On PMRF range	M3R recording made	Sightings and comments
1	16–20 February 2009	DDG	No	Yes	Yes	No	Nine sightings of 19 animals (humpback whales and unidentified sea turtle); Pilot MMO effort
2	27–29 August 2009	CG	No	Yes	Yes	No	No sightings; pilot MMO effort
3	16–22 February 2010	FFG	Yes	Yes	Yes	No	29 sightings of 45 animals (humpback whale, sperm whale, striped dolphin, rough-toothed dolphin); beginning of LOE protocol in HRC
4	12–16 November 2010	CG	Yes	No	No	n/a	Eight sightings of 54 animals (Green turtle, spinner dolphin, spotted dolphin, unidentified whale); first LOE on CG in any range complex
5	15–18 February 2011	DDG	Yes	Yes	Yes	Yes	22 sightings of 96 animals (humpback whale, spinner dolphin, short-finned pilot whale); first time M3R recordings made during exercise
6	19–22 February 2011	DDG	Yes	No	No	n/a	14 sightings of 100 animals (humpback whale, striped dolphin, Risso's dolphin, green turtle)
7	10–17 November 2011	DDG	Yes	No	Yes	No	Seven sightings of 84 animals (short-finned pilot whale, rough-toothed dolphin)
8	13–17 February 2012	DDG	Yes	Yes	Yes	Yes	14 sightings of 39 animals (humpback whale, short-finned pilot whale)

Notes: LOE = Lookout Effectiveness; DDG = destroyer, CG = cruiser, FFG = frigate, n/a = not applicable, MMO = marine mammal observer, HRC = Hawaii Range Complex, M3R = marine mammal monitoring on Navy ranges

It is also notable that due to the offshore nature of Navy exercises, environmental conditions in exposed waters away from the lee of islands are often not conducive to sighting marine mammals. Figure 3.6-3 shows survey tracklines from the MMO effort with color coding according to BSS.

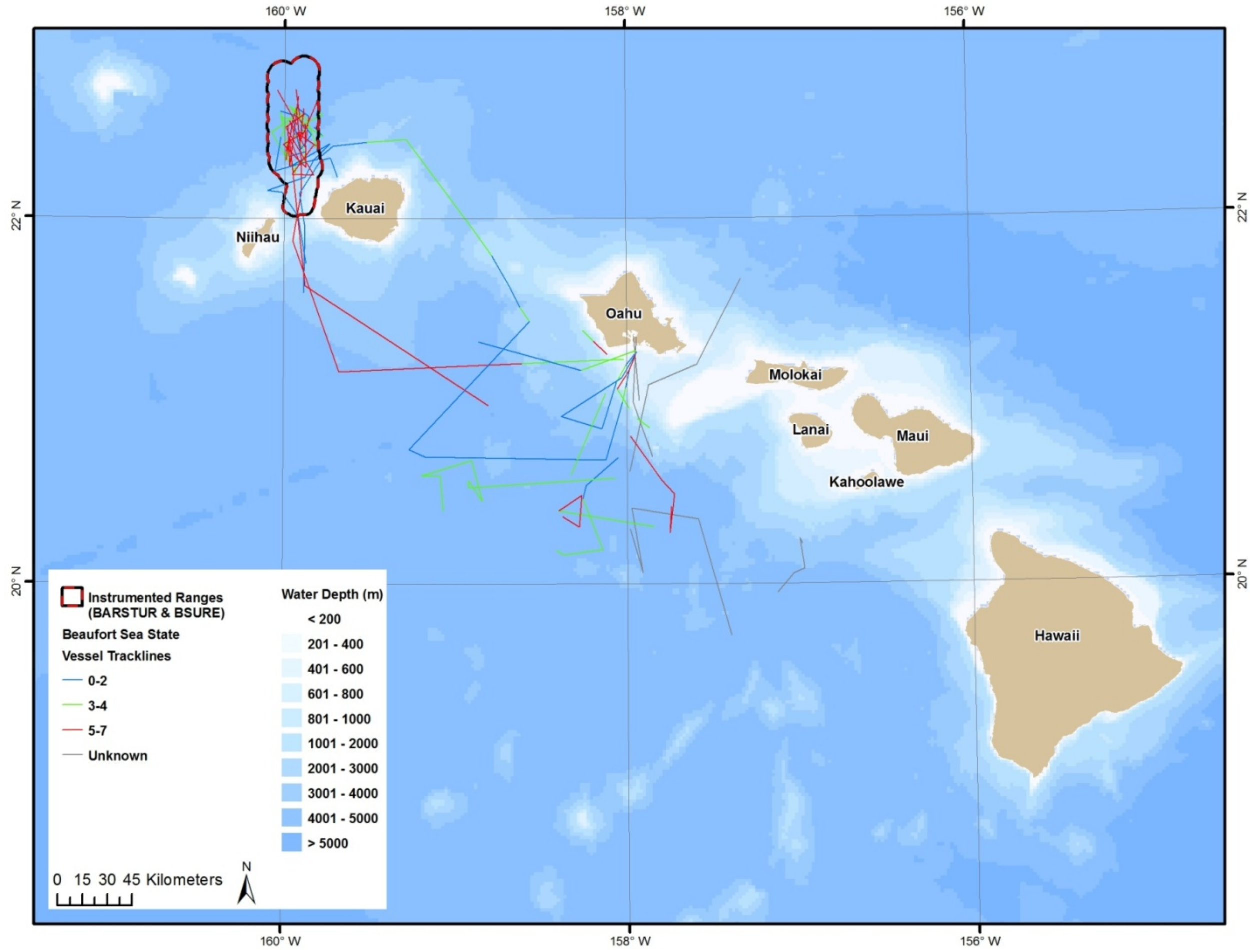


Figure 3.6-3: Survey Tracklines for MMO Surveys 2009–2012. Excerpt from Appendix A: Figure 7. All sightings and effort from monitoring efforts in the HRC, 2005–2012.

Major accomplishments related to this project to date include initial development of data collection protocols and analytic methods, data collection trials, completion of a proof-of-concept for detection functions, consultation with NMFS technical staff for input on analysis methods, and investment in continued refinement of the analytic methods and focus on additional data collection for the future.

Navy Fleet training organizations are currently evaluating the preliminary results from the proof-of-concept phase to determine if improvements in LO training programs are warranted. Initial steps in progress include evaluating incorporation of marine mammal survey techniques into watchstander training and revision of Marine Species Awareness Training. As more data becomes available, other options for improving LO training will be evaluated as appropriate.

3.7 VISUAL MONITORING

The U.S. Navy has been funding visual monitoring effort in HRC since 2005. In 2011, to facilitate analyses across all surveys, an initial effort to compile this entire corpus of survey data into Geographic Information System via a single georeferenced database was initiated (Uyeyama 2011), and continued in 2012 (HDR, Inc. 2012a). The latest iteration of this process applied analysis of questions across the database, and is presented in Appendix A (HDR, Inc. 2012b). This report summarizes 58 visual surveys and all sighting data from 2005 to 2012, including maps of effort by sea state and also sightings. Excerpted below from this report is a map showing an overview of all sightings and effort from monitoring efforts in the HRC (Figure 3.7-1). For clarity, sightings of humpback whales and sea turtles have been separated from all other marine mammal sightings.

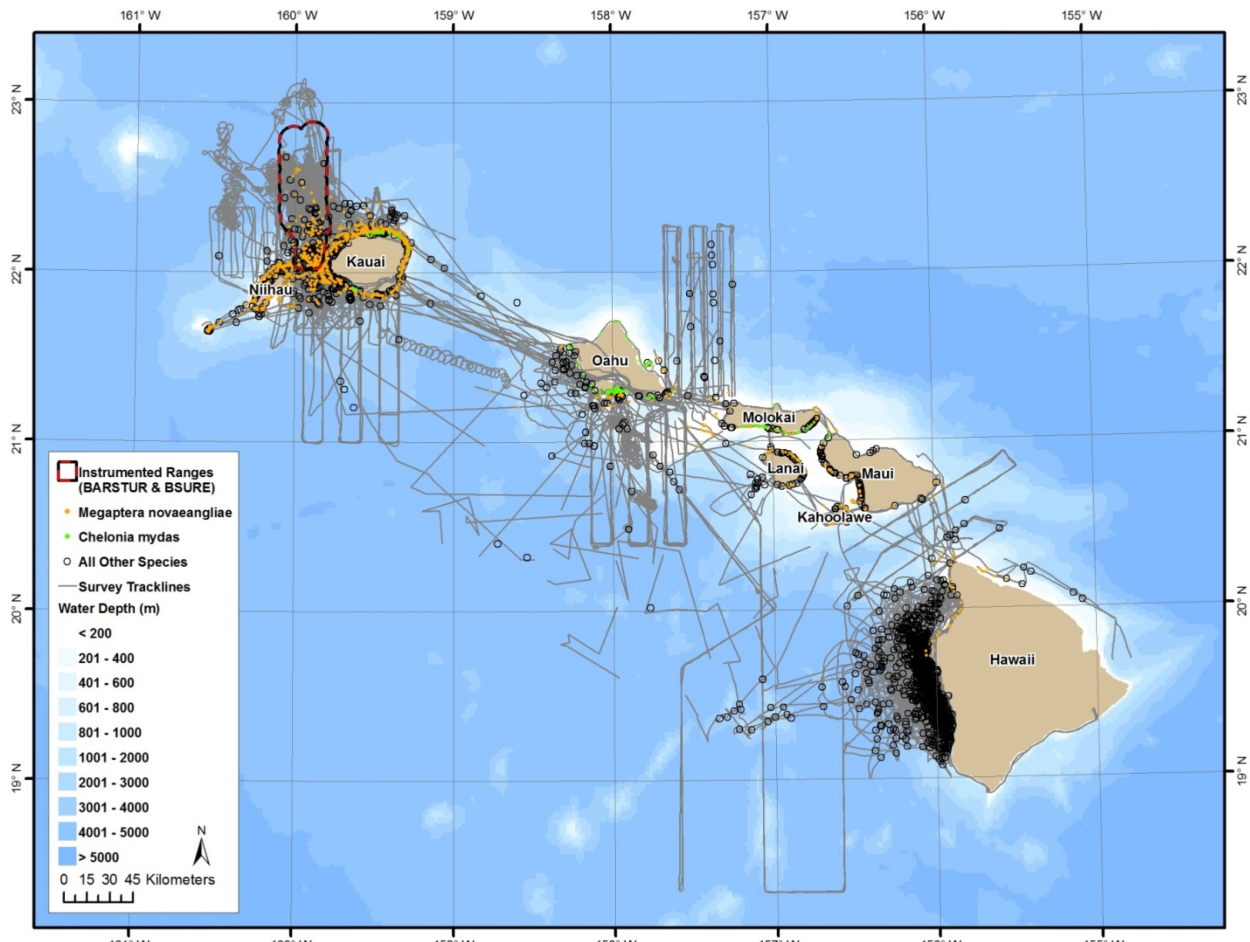


Figure 3.7-1: Excerpt from Appendix A: Figure 7. All sightings and effort from monitoring efforts in the HRC, 2005–2012.

Surveys had varying goals including pilot or feasibility surveys, baseline monitoring, monitoring during MTEs or smaller training events, and monitoring during UNDETs. Survey platforms were either aerial or vessel, and in some cases were platforms of opportunity rather than dedicated to the survey. For an in-depth summary of all surveys categorized by survey type, see Appendix A. For a discussion of the result of several types of survey, see Sections 3.3, 3.5, and 3.6.

While the different survey types focused on different goals, one goal of the Atlas project, a geo-referenced database of all sightings made during monitoring, was to assess what could be accomplished by looking at the entire body of visual data. Two questions were asked of the visual survey data: "Does sighting rate vary by survey platform?" and "Is there a relationship between BSS and sighting rate?" Because the surveys were conducted to serve diverse purposes and therefore had diverse designs, ability to utilize the entire body of data to answer broad scale questions of occurrence or habitat use was limited.

Sighting rates were calculated as sightings of all species per kilometer (sightings/km) of survey effort. They were compared by platform type as well as for dedicated vs. non-dedicated survey protocols. Sighting rates for all species on dedicated survey platforms were higher than on non-dedicated platforms (0.029 and 0.016 sighting/km, respectively). Sighting rates were also higher on vessel platforms (0.033 sighting/km) than on aerial platforms (0.017 sighting/km). These results were statistically significant; however, other variables that could affect sighting rates were not included in the analysis.

Sighting rates of humpback whales were examined in relation to survey platform and BSS. Humpbacks were selected because they are the most abundant sightings and were the species which would provide the largest sample size. When sighting rate was plotted relative to sea state, there appeared to be a general trend for higher sighting rates to occur at lower BSS. However, these results were not statistically significant. Humpbacks are highly salient relative to other species and exceptionally visible during high BSS and the lack of significance could be related to sample size (n=44).

Spinner dolphins were the most frequently encountered cetacean followed by humpback whales, pantropical spotted dolphins, and short-finned pilot whales. The regions with the highest levels of visual effort (also of diverse methodologies) in HRC are PMRF, off the south coast of Oahu, and off the west coast of the Island of Hawaii. There has been relatively little visual effort near Molokai; Maui; Lanai; the north coast of Oahu; the north and east coast of Kauai; the areas west and southwest of the PMRF around Niihau; the area south of the Kaulakahi Channel (Kauai/Niihau channel); the deep waters around Kaula, southwest of the range; waters around Middle Bank, northwest of the PMRF; or the north and east coasts of the Island of Hawaii and the deeper waters and seamounts to its far west that lie directly south of the four-island region and Oahu. In general, waters of the PMRF range are the most well-sampled visually, while some areas surrounding the range have never been surveyed, or are rarely surveyed. The result is that it is difficult to draw conclusions about animal movements on and off the instrumented range in response to training exercises with visual data alone.

4 NAVY BASIC AND APPLIED RESEARCH SUMMARY (ONR, N45)

The ONR Marine Mammals and Biology (MMB) program and LMR (formerly OPNAV N45 program) funds are applied to marine mammal research projects, some of which take place within the HRC. These projects have been summarized in the Navy's Annual Marine Species Monitoring Reports (Department of the Navy 2009b, 2010b, 2011b, 2012b).

4.1 Research Results with Respect to Monitoring Questions

The Navy's Research and Development program, the ONR MMB program, supports basic and applied research and technology development related to understanding the effects of sound on marine mammals, including physiological, behavioral, ecological effects and population-level effects. Their current program thrusts include, but are not limited to:

- Monitoring & Detection
- Integrated Ecosystem Research (including Sensor & Tag Development)
- Effects of sound on marine life: Hearing, BRSs, Physiology (Diving & Stress), Population Consequences of Acoustic Disturbance
- Models & Databases for Environmental Compliance

Both the OPNAV N45/LMR and ONR programs invest a portion of their resources in the HRC, the highlights of which are summarized in Table 4.1-1. Further detail on these projects may be found in Department of the Navy 2009, 2010, 2011, 2012 and at http://www.onr.navy.mil/Science-Technology/Departments/Code-32/All-Programs/Atmosphere-Research-322/Marine-Mammals-Biology.aspx and www.lmr.navy.mil.

Table 4.1-1: Summary Table of Basic and Applied Research in Hawaii Range Complex 2009–2012

YEAR	ONR	N45
2009	1. The ecology and acoustic behavior of wintering minke whales in the Hawaiian and Pacific Islands – Tom Norris (BioWaves), Steve Martin (SSC Pac), University of St Andrews, and Eva Nosal (University of Hawaii, School of Ocean and Earth Science Technology) 2. Remote Passive acoustic marine mammal monitoring including foraging of beaked whales (2009 only) – Whitlow Au and Marc Lammers (HIMB) 3. Research on hearing and echolocation of marine mammals – Paul Nachtigall (HIMB) 4. Tracking with widely spaced bottom mounted hydrophones – Eva Nosal (University of Hawaii, School of Ocean and Earth Science Technology) 5. Develop a low-cost sensor system that can be easily deployed and signal interpreted for estimating the range, direction, size and type of marine species in a volume of ocean – Guide Star Engineering 6. DECAF Effort – Len Thomas (University of St. Andrews CREEM), Dave Moretti (NUWC), Peter Tyack (Woods Hole Oceanographic Institution), Dave Mellinger (Oregon State University) and Steve Martin (SSC Pac) participation	1. HARP Deployment of Hawaii Island – Erin Oleson (Pacific Islands Fisheries Science Center), John Hildebrand (Scripps Institution of Oceanography) 2. Odontocete tagging – Robin Baird (Cascadia Research Collective)
2010	Continuation of 1, 2, 3, 4, 6 from 2009	Continuation of 1, 2 from 2009

YEAR	ONR	N45
	7. Development of Improved Satellite-Linked Transmitters, Physiological Recorders, and Attachment Techniques for Monitoring Beaked Whales – Russ Andrews, Greg Schorr, Robin Baird (Cascadia)	
2011	Continuation of 1,2,3, 4, 7 from 2009, 2010 8. Development and trial of glider and humpback whale classifier – Philip Abbot (Ocean Acoustical Services and Instrumentation Systems [OASIS]), Inc. 9. Utilizing Pro-Bono Commercial Assets for Marine Mammal Surveys in a High Naval Activity Area in Hawaiian Waters – Whitlow Au and Alexis Rudd (HIMB)	Continuation of 2 3. M3R at PMRF, NUWC Newport
2012	Continuation of 2, 3, 4, 7, 8, 9 10. Use of Electronic Tag Data and Associated Analytical Tools to Identify and Predict Habitat Utilization of Marine Mammals – Daniel Costa and Barbara Block (University of California at Santa Cruz) 11. Importance of Thin Plankton Layers in Hawaiian Food Web Interactions: Research Spanning From Physical Circulation to Spinner Dolphins – Kelly Benoit-Bird and Margaret McManus (Oregon State University and University of Hawai'i at Manoa)	Continuation of 2,3

Notes: (1) This table might not fully represent all N45 and ONR efforts in the HRC. Some projects may have overlap into the HRC of which the authors are unaware; (2) CREEM = Centre for Research Into Ecological and Environmental Modeling, DECAF = Density Estimation of Cetaceans using Acoustic Fixed sensors, HARP = High-frequency Acoustic Recording Package, HIMB = Hawaii Institute of Marine Biology, M3R = marine mammal monitoring on Navy ranges, NUWC = Naval Undersea Warfare Center, ONR = Office of Naval Research, PMRF = Pacific Missile Range Facility, SSC Pac = Space and Naval Warfare Systems Center Pacific

The OPNAV N45 program underwent a formal revision to become the LMR Program with administration of the program passing from OPNAV N45 to Naval Facilities Engineering Command and Expeditionary Warfare Center in Port Hueneme, CA in 2012. The new program Advisory Committee has members of the Fleet and ONR marine resources program which will streamline the commands efforts. The LMR developed new "Needs" which will be used for soliciting proposals in early 2012.

Most of the larger Navy R&D Projects, such as the Southern California BRS occur in other range complexes. In the HRC, the most significant one is the M3R project, which is summarized in Section 3.3.

Tag and PAM device development in the HRC and elsewhere have led to technology and methods that are used in the HRC. OPNAV N45, now the LMR program, has been funding CRC in the HRC for several years. The CRC studies have led to significant baseline knowledge of odontocete occurrence, distribution, and habitat use within the HRC. Results of this research can be found at www.cascadiaresearch.org/hawaii/hawaii.htm. EAR development and deployment by Hawaii Institute of Marine Biology, as well as significant work with automated detectors and classifiers, have also provided significant baseline data on marine mammals in the HRC in addition to the tools themselves.

5 PROGRESS ON MONITORING QUESTIONS AND COST BENEFIT COMPARISON

This section is a brief discussion of the progress that has been made on the five original monitoring questions during the monitoring period from August 2008 through July 2012. In-depth discussion of results and what has been learned from individual monitoring studies is found in many of the other sections of this report. This section will attempt to summarize the intellectual "distance" that has been covered with respect to each monitoring question (Section 5.1), the cost efficiency of the various methods of monitoring at delivering useful information toward the answering of questions (Section 5.2), and some lessons learned from establishing and executing a large-scale monitoring program in HRC (Section 5.3).

5.1 PROGRESS ON MONITORING QUESTIONS

The five monitoring questions have some areas of overlap; therefore, some studies provide information for more than one study question. The best studies, from an efficiency perspective, provide insight into several questions, thus contributing to progress on several fronts at the cost of a single study. When considering the below, the reader will notice redundancy in the information and progress between some questions. An ongoing contracted data analysis effort (Appendix C) considers the entire body of monitoring data and how they address the five monitoring questions.

1. Are marine mammals and sea turtles exposed to mid-frequency active sonar, especially at levels associated with adverse effects (i.e., based on NMFS' criteria for behavioral harassment, TTS, or PTS)? If so, at what levels are they exposed?

Evidence from aerial monitoring and MMO embarks on PMRF definitively establish that marine mammals have been observed in the vicinity of Navy vessels that are operating MFAS (see Section 3.3). The animals are definitely within distances that would allow sonar to be detected above ambient noise. The majority of marine mammals that have been observed to be in the vicinity of Navy vessels that could be using MFAS on PMRF have been primarily odontocetes. Unidentified blackfish and turtles have been observed relatively close to active vessels (Box 51). In addition, the records of mitigation actually being implemented by Navy vessels that are training shows that some animals come within distances to vessels that require mitigation actions that comply with mitigation procedures (see Section 2.1.1). The location of some species, such as minke whales and beaked whales, have been inferred from acoustic monitoring on PMRF (see Boxes 32 and 47 and Section 3.3) and calculations have estimated that these species have received SPLs from about 115 dB re 1 μPa to 164 dB re 1 μPa. A pair of humpback whales near a vessel was estimated, in a worst case scenario, to received SPLs as high as 196.9 dB re 1 μPa, a level that could exceed TTS for humpback whales. There is a high degree of uncertainty to these estimates, but the worst case scenario is a maximum value for exposure. Other species are known to spend time on PMRF from tag data, sightings, and M3R detections. These species include bottlenose dolphins, false killer whales, melon-headed whales, rough-toothed dolphins, short-finned pilot whales, sperm whales, and spinner dolphins. Because tag and photo-identification information suggests that some of the individuals observed and tagged are resident to the area, these species are likely to have experience with hearing MFAS, even if only at a great distance. Additional species which have been sighted on PMRF include minke whales, Blainville's beaked whales, unidentified beaked whales, killer whales, pantropical spotted dolphins, striped dolphins and spinner dolphins.

2. If marine mammals and sea turtles are exposed to mid-frequency active sonar, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last?

This question is challenging to address because it requires knowledge of baseline animal distribution and movement across a wide area and multiple time scales, animal movements when MFAS is in use, detailed ship position and MFAS data, and a long enough data collection period to observe a change in distribution after MFAS has ceased. To date, most studies have not yet addressed collecting data on these scales. On PMRF, M3R data can detect and localize where species are vocalizing and that implies where the animals are geographically (at least the ones that are vocalizing), but the system is relatively new. While studies are underway, patterns of distribution around sonar training has yet to be established. Some PAM devices were placed near PMRF with the intent to understand if detections of species increase in areas adjacent to the range during times MFAS is in use. Insufficient analysis has been accomplished so far to make a determination, and therefore refinement of the goals of analysis is required and in process.

3. If marine mammals and sea turtles are exposed to mid-frequency active sonar, what are their behavioral responses to various levels?

Knowing the behavioral response of marine species to MFAS requires either close observation of animals in the presence of MFAS or devices affixed to the animal that can acquire data on the animals behavior as MFAS occurs. Preferably the device on the animal can measure the RL of sound. Applying tags that would accomplish the latter measurements has not yet been achieved in HRC, but some observations of cetacean behavior have been collected from aerial platforms in the presence of MFAS. The data sets are small, but there are proposed methods for obtaining information from the data sets. The approach for analyzing the data sets during Monitoring Year Five is detailed in Section 3.3.3 and Appendix C.

4. What are the behavioral responses of marine mammals and sea turtles that are exposed to explosives at specific levels?

The Navy has conducted monitoring during UNDET training (Boxes 15, 26, 37, 43 and 44), but no species have been observed as explosives events are occurring. All mitigation has been executed correctly when monitoring has occurred, so turtles and marine mammals have not been present to be observed for behavioral changes during events. No marine species were observed during SINKEX monitoring in 2010 (Box 25).

5. Is the Navy's suite of mitigation measures for mid-frequency active sonar and explosives (e.g., PMAP and major exercise measures agreed to by the Navy through permitting) effective at avoiding TTS, injury, or mortality of marine mammals and sea turtles?

Data from mitigation events that have occurred in HRC during ASW training suggests that mitigations actions have been applied when appropriate. Operators have been conservative enough to over-mitigate for marine species that are at distances from MFAS that are greater than what is required. Given this information, it appears that implementation of mitigation measures is preventing harmful exposure to marine species.

For detonation events, all mitigation has been executed correctly when monitoring has occurred. No turtles or marine mammals have been observed or reported harmed from explosives in HRC.

There is an ongoing LOE study with MMOs on Navy vessels that is attempting to quantify the effectiveness of mitigation applied on Navy vessels. This study is discussed in Section 3.6.2.

5.2 COST-BENEFIT ANALYSIS

During the period of August 2008–July 2012, the Navy has expended approximately $5.7M on monitoring efforts in the HRC. The goal of this section is to break this overall cost into components, and report the costs and benefits from each component. The objective of a cost-benefit analysis of the Navy marine species monitoring program in the HRC is to quantify the return on investments (ROI) in monitoring. Such an analysis is a complicated matter, because the monitoring program is diverse in methodologies and the sample size of monitoring studies for any particular method is relatively small (in most cases less than 10 studies). Additionally, the units with which return has been measured are largely those of level of effort or data gathered; however, since each methodology varies with regard to its overall contribution to the full range of goals of the ICMP, a ROI for one methodology may not be directly comparable with that from another, even when the resulting units of ROI seem comparable. As is the case with programs that are as young as this monitoring program—less than a decade—there have been adjustments during the first years while the program was settling into a productive structure and pace. The Navy has tried several pathways for funding and executing monitoring which include:

- The Navy executing monitoring in-house
- Contracting monitoring to individual scientists
- Seeking expertise from universities
- Using the services of other government agencies
- Large contracts with companies that can bundle a variety of services under one management structure

At this time, a combination of the above pathways is being utilized and this is expected to continue. This approach, while it achieves many desirable outcomes, makes it challenging to analyze the costs and benefits.

In general, any type of at-sea monitoring is expensive given the unpredictable environment (e.g., weather, ocean conditions), and distances from shore based infrastructure (ports, power supplies, airfields). The Navy's monitoring is no exception and faces many of the same challenges. Additionally, in the HRC, low densities of animals often result in few sightings; however, the value of those sightings particularly when behavior is observed in conjunction with a training event is very high. For the HRC, across the duration of the monitoring so far (2009–2012), few costs have remained the same (MMO) but have in most cases gone up (PAM, aerial), primarily due to increased costs for analysis needed for the volume of data being collected.

One of the key changes which has occurred over time and confounds the analysis is the way that monitoring progress and results are measured. Reports from early studies provided results in a basic manner such as the number of kilometers of trackline traveled on a survey and the number of sightings observed during the survey. This translates simply into a metric such as sightings/km. At the commencement of TAP, Phase 1 monitoring, a new metric was implemented—the amount of time spent monitoring. This new metric clearly provided the amount of effort the Navy had spent monitoring and could be easily reported to the NMFS as required by the MMPA and ESA. Unfortunately, this created a break in continuity from past monitoring efforts. With the new emphasis on time, quantitative values such as the amount of distance covered were reported inconsistently in monitoring reports; therefore, not all studies performed over time can be compared to each other, unless generalizations or estimates are generated. As a result of this discontinuity, some studies cannot be compared or combined with others.

Another confounding factor for the analysis is the different contracting methods which were used. In most cases, the easiest monitoring efforts to analyze are the stand-alone studies contracted to a single-service provider. In that case, it is clear that the planning, preparation, execution, and reporting are attributable to money allocated to that contracted study. However, when the Navy performs work in-house or combines monitoring tasks into a single contract, it becomes difficult to determine what portion of aggregate tasks, such as planning or data management, support individual surveys or data collection devices. A result of this difficulty in assigning costs to specific efforts is that the exact costs cannot be clearly determined. This is not to say that in-house monitoring or combining efforts into a single contract should be discontinued. There are many benefits to doing so—such as enhanced planning and collaboration. This discussion is simply intended to outline the confounding factors of the cost-benefit analysis.

Given the above limitations, an attempt has been made to provide information on the cost of results obtained by the Navy monitoring program in terms that are reasonable and understandable. A common objective of monitoring is the determination if species of concern are present in the area of interest or potential impact. A typical measure of this is the number of detections or sightings made of a particular species. In this analysis sightings or detections are put in the most useful context possible, such as sightings/km or detections/unit of time. For this report, the day was selected as the most logical unit of time, although it is coarse. It was selected because, when monitoring occurs, effort or platforms are typically purchased in days. How the platform or service is used on that day is of little consequence in the end. For example, if the plane flies for half of the day and sits on the tarmac for the second half because of a storm, the pilots and the airplane have already been purchased for the day. If MMOs are out on a boat and the visibility is poor that day, the MMOs are paid for a day's service even though the conditions would not allow them to see anything. All of the planning ahead of time and all of the reporting and analysis afterward (both of which contribute to the cost) may be viewed through the metric of data collected during the days in the field. Therefore, the days of monitoring purchased will be used, along with some other measures when possible, to quantify Navy monitoring in terms of time. Ultimately, an effective approach would be to quantify the results of the funds spent on monitoring, evaluate which methods give the highest return on investment, and try to make choices that maximize the amount of information obtained by choosing monitoring efforts that provide the most value. Like other elements in the monitoring program, monitoring funding decisions should be based in scientific merit and statistical rigor as well as monetary efficiency.

Cost values per detection or sighting have a high level of variation due to the variance in the rate of sighting or detection by platform and methodology, but also by the fact that costs have changed over time. For example, vessel surveys have grown in cost, by at least an order of magnitude since 2005. Figure 5.2-1 and Figure 5.2-2 show the cost per day of aerial surveys since 2006 and vessel surveys since 2005; the general trend is upward, although there is a great deal of variation. This is partially due to the fact that more sophisticated efforts are being planned and more costly platforms are being used. Early surveys used a sail boat, which has relatively low fuel costs. Later surveys have used larger vessels with more expenses and more room to support a larger effort. Variations like these needs to be taken in to account when cost values are being considered. Some cost increases in more recent years are due to the program's growth into a more complex endeavor. The management of a multi-faceted field approach being accomplished by a large-scale contractor has replaced the in-house oversight by a Navy Technical Representative of an individual researcher on an individual purchase order or sole source contract.

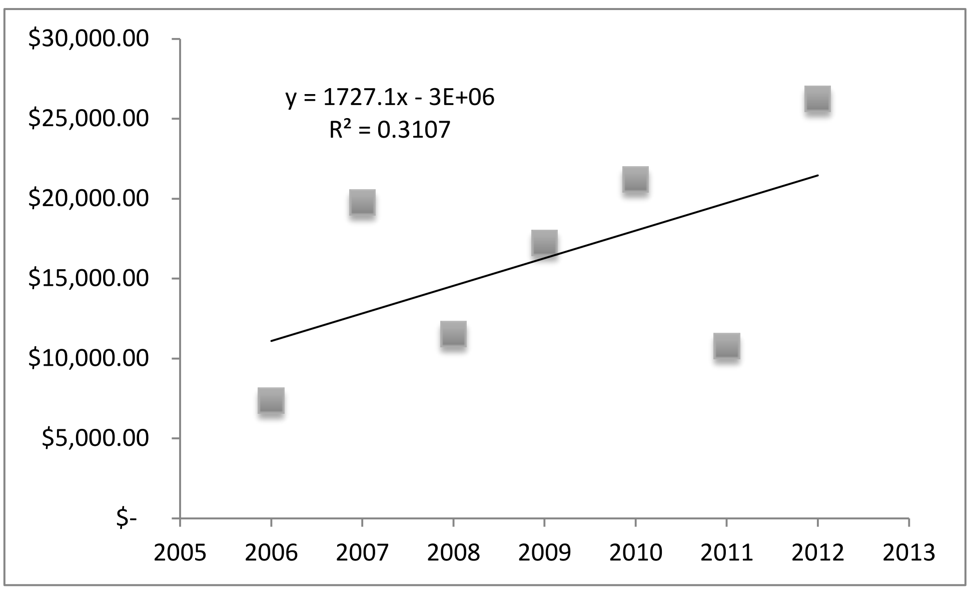


Figure 5.2-1: Average Cost Per Day for Aerial Surveys Since 2006. Sample sizes are small for every year.

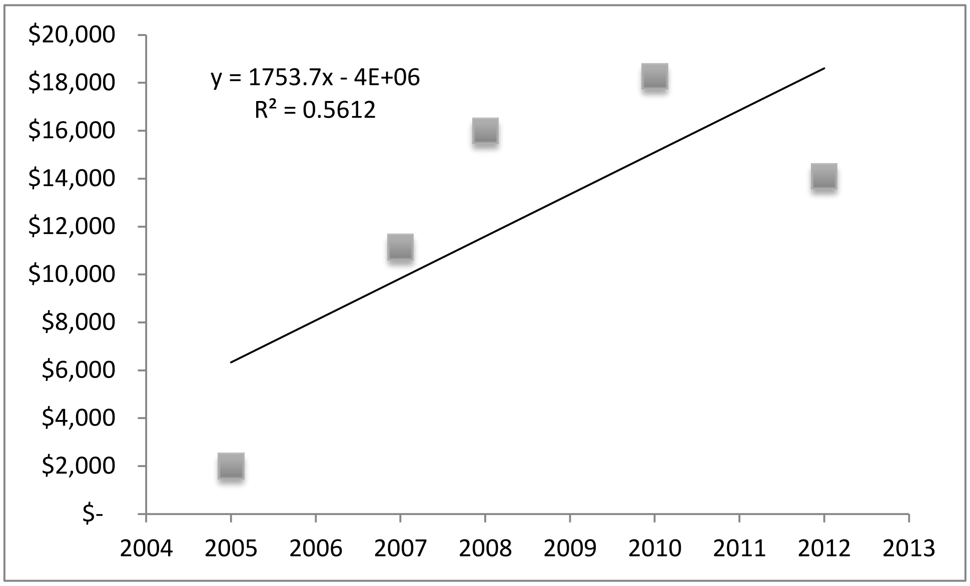


Figure 5.2-2: Average Cost per Day for Medium and Large Surveys Since 2005. Sample sizes are small for every year.

5.2.1 Cost Analysis

Table 5.2-1 summarizes the rates of detection for two visual platforms commonly used during Navy marine mammal monitoring: aerial surveys and vessel surveys. Although a number of surveys were conducted for each method, not all surveys could be included. To allow for a larger sample size, surveys since 2005 have been included.

The values on Table 5.2-1 show that, generally speaking, the rate of detection of marine species is greater in the cool season than it is during the warm season. For this analysis cool season is November to April, and warm season is May to October. The first column is sightings of all marine mammals and sea turtles, including hauled out monk seals. The second column considers sightings of cetaceans only. The difference between the seasons in both columns is attributable to the fact that humpback whales migrate in large numbers to the Hawaiian Islands in the winter. Although other baleen whales are thought to also do this in lower numbers, humpbacks typically occur near shore and are relatively easily seen, even in higher sea states. Removing humpback whales from consideration is not meant to discount their importance or presence. It is important to understand their occurrence, but a number of past and ongoing studies already addressed that issue (e.g., Craig and Herman 1997, Helweg and Herman 1994, and Mobley et al. 2001). For this analysis, comparing sighting data from summer to winter is fraught with problems if humpback whales are not taken into account. When corrected for occurrence of humpback whales, the rates of sighting become more similar. For vessel surveys the rate in the cool season is still about twice that of the warm season. That difference may be due to sightings of unidentified large whales, some of which may be humpback whales or other species of mysticetes. Aerial survey sighting rates are much more similar when the sighting rates are corrected for humpbacks (0.0055 sighting/km cool season vs. 0.0045 sighting/km warm season, Table 5.2-1). Considering standard error, the values are not statistically different.

Table 5.2-1: Rates of Detection of Sightings and Costs per Sighting. Values are means with standard error in parentheses below.

Season	Rate of detection (sightings/km)	Rate of detection cetaceans (sightings/km)	Rate of detection cetaceans other than humpback (sightings/km)	Cost per sighting ($/sighting)	Cost per sighting of cetaceans ($/sighting)	Cost per sighting of cetaceans other than humpback ($/sighting)
Cool season vessel (n=6)	0.0925 (0.0334)	0.0925 (0.0334)	0.0211 (0.0041)	$3,650 ($2,046)	$3,945 ($2,302)	$6,059 ($1,993)
Warm season vessel (n=3)	0.0113 (0.0011)	0.0107 (0.0004)	0.0107 (0.0004)	$10,010 ($6,413)	$10,790 ($7,229)	$10,790 ($7,229)
Cool season aerial (n=4)	0.0416 (0.0111)	0.0267 (0.0117)	0.0055 (0.0014)	$1,150 ($557)	$2,699 ($1,684)	$21,858 ($13,818)
Warm season aerial (n=3)	0.0055 (0.0016)	0.0045 (0.0020)	0.0045 (0.0020)	$3,694 ($470)	$14,109 ($8,960)	$14,109 ($8,960)

Note: km = kilometers

The general seasonal pattern of cost is the same for both platforms. Costs per sighting are more expensive in the warm season than in the cool season. When corrected for the presence of humpback whales though, that changes for aerial surveys. Costs become greater per sighting in the cool season than in the warm season. This may be due to the fact that high sea states in the winter make it difficult to see marine mammals that are smaller than humpback whale, so the other species are detected at lower rates. It is notable that the standard error values for the cost figures are high.

Aerial Visual Surveys

Considering general number for the visual platforms may not be a fair assessment of the viewing potential of a platform. There are factors that affect the detection rate that are not inherent to the platform. Aerial platforms for example are used in three different ways during Navy monitoring: systematic pattern surveying, closely accompanying Navy vessels using elliptical "orbiting" patterns, and shoreline surveys. Each of these conditions affords the MMOs in the aircraft different opportunities to see marine mammals. MMOs on an aircraft accompanying a Navy ship are following a pattern determined by the ship operators. Standard tracklines sample the environment in a systematic manner. Shoreline surveys run parallel to environmental features (bathymetric contours) that may aggregate marine species, and thus they may acquire higher sighting rates, while flying systematic transects will sample the environment in a less biased manner.

Values for costs of aerial surveys are broken down by their type of survey pattern in Table 5.2-2. Values are provided for all sightings and for cetacean sightings with humpback whales removed to standardize between seasons. Values for sightings/km cannot be given, because trackline data was not generally reported by the type of pattern being flow, so cost is being used as a proxy.

Table 5.2-2: Costs for Aerial Surveys Broken Out by the Type of Survey Pattern. Values are means with standard error in parentheses below. Not every pattern was flown during every monitoring effort. Sample size is below the standard error.

		All Marine Species			Cetaceans Without Humpback Whales		
Season	**$/day**	**Systematic Survey ($/sighting)**	**Accompany Navy Vessel ($/sighting)**	**Shoreline Survey ($/sighting)**	**Systematic Survey ($/sighting)**	**Accompany Navy Vessel ($/sighting)**	**Shoreline Survey ($/sighting)**
Cool season	$19,485 ($2,773) n=6	$2,198 ($1,993) n=5	$5,802 ($3,191) n=4	$384 ($169) n=5	$6,817 ($2,834) n=5	$24,451 ($12,239) n=4	$5,607 ($3,020) n=5
Warm season	$14,001 ($3,091) n=5	$4,692 ($956) n=5	$20,102 ($21,307) n=2	$710 ($205) n=4	$5,855 ($1,339) n=5	$20,102 ($21,307) n=2	$5,560 ($2,422) n=4

For this analysis seeing a single sighting during any type of effort and seeing no sightings was treated the same, because both situations provide one data point. For example, if it costs $15,000/day to fly and a crew flew a systematic pattern for 3 days and saw one sighting, the cost of that sighting would be calculated by 3 days x $15,000 ÷ 1 sighting = $45,000/sighting. The value is the same if there are no sightings, because the $45,000 would have been spent for the 3 days of survey. In addition, a zero is still data. It tells the Navy that no marine species, distressed or otherwise, were detected at that location and time under those conditions.

There are two things that are clear from looking at the Table 5.2-2. First, accompanying the Navy vessel is the most expensive option for obtaining data about species presence. When humpback whales are present and all species are considered, the cost is a little more than twice the cost of a day of systematic survey. When humpback whales are not present or are removed from the data, the cost difference is about four times, whether turtles and monk seals are included or not. This survey pattern also has the most variable cost data evidenced by high standard errors (which are partially a result of the small sample size). Second, the cost/sighting of shoreline surveys is not much different from systematic surveys for generally observing cetaceans, but they are quite effective for observing humpback whales, which occur near shore, and species other than cetaceans. In this case, shoreline surveys obtain data on Hawaiian monk seals that are hauled out and sea turtles in the nearshore water, where they spend most of their time (Brill et al. 1995; Hazel, Lawler, and Hamman 2009). Shoreline surveys are efficient enough at detecting nearshore species that the cost/sighting is about an order of magnitude below systematic surveys. Interestingly, a primary objective of shoreline surveys is to observe any strandings that may occur after Navy training; to date, no strandings have been observed.

It is important to keep in mind that collecting sightings is not the only objective of many surveys. When investigating the short-term effects of MFAS used during Navy training events on animals, a crucial component of making progress toward this question is gathering data during and near an actual Navy training event that involves MFAS. Such data could be gathered by acoustic methods such as the instrumented range, or by high fidelity tags such as Digital Acoustic Recorder Tags (DTAGs) deployed during BRSs, or by inserting visual survey platforms into a Navy exercise. As past experience has shown (Boxes 29–31) the difficulty of effectively placing surface survey vessels near enough to an exercise, if a visual platform is desired, the remaining alternatives are MMOs on Navy vessels, or an aerial platform. For instance, when a plane is accompanying a Navy vessel, one of the major objectives is to obtain information about the behavior of species of concern that are spotted near the vessel and the spatial relationship of the animals to the vessel. For the MMO on a Navy surface ship, opportunities are very limited since the observer does not have control of the platform and therefore, cannot conduct a traditional focal follow. Since marine species need to be spotted before they can be observed in detail and only a subsample of sightings can be tracked in a focal follow for an appreciable period of time, the question at hand is whether the cost of capturing these rare events is worth the money spent. Since this is perhaps the only way to capture this data, those few data points, while costly, may provide valuable behavioral data. Of the surveys analyzed here, 12.97 survey days have been spent with the vessel. During that time, 23 sightings have been made in the presence of vessels; 21 of those sightings have been humpback whales. No sightings have been made during summer surveys (they were discontinued as a result), which are comprised of 4.7 survey days accompanying ships. Focal follows were executed on six of the 23 sightings. Appendix B discusses the analysis of focal follows. At an average cost of \$16,992/day (across seasons) of orbital surveys, each focal follow was obtained at a cost of \$36,731 (12.97 days x \$16,992/day ÷ 6 focal follows). As discussed earlier, this cost should be viewed knowing that the surveys' occurrence further offshore in order to survey in conjunction with a training event and the likelihood of surveying in higher BSS than is optimal inherently reduces sighting likelihood.

Vessel Visual Surveys and Cetacean Tagging

Vessel surveys can be subject to challenges of interpretation similar to aerial visual surveys. Vessels of different sizes cost different amounts to lease and operate—typically smaller vessels cost less than larger vessels. The monitoring objective usually determines the type of vessel used for the study.

Two types of vessel visual survey activities are used in Navy monitoring: visual searching and tagging. Tagging activities provide much of same information that visual searching does, including sightings, positions, photo-identification, and environmental information. In addition, tagging efforts deploy tags, which are considered separately. Table 5.2-3 and Table 5.2-4 contain the sighting rates and cost values for vessel surveys and tagging surveys.

Table 5.2-3: Sighting Rates for Vessel Surveys Broken Out by the Type of Vessel. Values are means with standard error in parentheses below.

Vessel type and season	Rate of detection (sightings/ km)	Rate of detection cetaceans (sightings/ km)	Rate of detection cetaceans other than humpback (sightings/ km)
Med/Large vessel cool season n=5	0.1039 (0.0385)	0.1039 (0.0385)	0.0182 (0.0035)
Med/Large vessel warm season n=2	0.0113 (0.011)	0.0106 (0.0004)	0.0106 (0.0004)
Small tagging vessel cool season n=1 Box 35	0.0357	0.0357	0.0357
Small tagging vessel warm season n=1 Box 54	Not yet reported	Not yet reported	Not yet reported

Note: km = kilometers

Table 5.2-4: Costs for Vessel Surveys Broken Out by the Type of Vessel. Values are means with standard error in parentheses below.

Vessel type and season	$/day	Cost per sighting ($/sighting)	Cost per sighting of cetaceans ($/sighting)	Cost per sighting of cetaceans other than humpback ($/sighting)
Med/Lg vessel cool season n=5	$10,758 ($2,533)	$4,215 ($2,408)	$4,569 ($2,714)	$7,106 ($2,078)
Med/Lg vessel warm season n=2	$18,532 ($2,548)	$14,697 ($4,041)	$15,868 ($5,212)	$15,868 ($5,212)
Small tagging vessel cool season n=1 Box 35	$2,691	$828	$828*	$828*
Small tagging vessel warm season n=1 Box 54	$1,934	$635	$635*	$635*

Note: Funding is leveraged, in many cases, by funding from other funding sources such as NMFS or Navy/LMR.

Focusing initially on the larger vessel surveys, it is interesting to note the similarity in rates of sighting cetaceans for warm and cool season surveys when corrected for the presence of humpback whales (0.0182 sighting/km cool season vs. 0.0106 sighting/km warm season). The information in the two tables indicates that the tagging effort in February 2011 (Box 35) had a higher rate of sighting than the mean rate of larger vessel surveys in either season. Visual surveying from a tagging vessel is also cost efficient, as is shown in Table 5.2-4. The cost per sighting is below $1,000 for both surveys. CRC, which has performed all of the Navy's cetacean tagging in HRC so far, uses a non-random, non-systematic survey methodology to search for target species. This method is designed to optimize the likelihood of interaction with species that are preferred for tagging. It is important to compare numbers between the two vessel types for cetacean sightings other than humpback whales, because CRC ignores humpback whales as they have not been a target for their tagging efforts.

Navy monitoring in HRC has been able to realize even greater cost savings during tagging efforts, because CRC is performing a variety of projects with funding from various Navy sources and NMFS (see Section 3.5.2 for more information). This arrangement has allowed for CRC to combine objectives when they work in the field. This has meant that, in many cases, the monitoring program pays for elements of a project, but some components (e.g., tagging team members) are supplied by other funding sources. In addition, of the two tagging efforts reported here, the June and July 2012 effort, leveraged with LMR funding and effort, was coordinated with the M3R research team on the PMRF instrumented range (see Section 3.3.3.2). Other efforts have indicated that M3R can guide tagging vessels to sightings. In July and August 2011 (Box 41), 37 percent of the sightings were cued by M3R acoustic detections, and in January 2012 (Box 46), 31 percent of the sightings were cued by M3R. Synergy between tagging and the M3R system is expected to be promising for leveraging the benefit derived from visual surveys on PMRF.

There are advantages and disadvantages to tagging surveys that should be recognized as contributing or limiting the benefits derived from tagging surveys. A limit to tagging vessels is the fact that they are small; therefore, they are limited in their range and the conditions in which they can operate. Except when a large vessel with the right layout is used as a platform (e.g., a NMFS research vessel) for the tagging team or exceptionally good field conditions occur, species that are found distant from shore are outside the limits of a tagging team much of the time. Conditions in Hawaii in general, and anywhere not in the lee in particular, often limit the location and time that a tagging team can operate. In general satellite tagging efforts have occurred in the deep water lees of Kauai, Lanai, and the Big Island. Fortunately the lee of Kauai roughly overlaps with the southern portion of the instrumented underwater training range at PMRF, and therefore the initial tagging of animals here coincides in space with an area of relatively high Navy training activity, as well as in recent years the area of the majority of other monitoring activities with which tag data might synergize.

An element that leverages the return from tagging surveys is the tags themselves. The cost of the tags that CRC has been deploying for Navy monitoring in HRC is between $3,500 and $5,000, including programming and Argos satellite data collection. Once a tag is placed on an animal, it essentially "re-sights" the animal each time it uploads positional information. For social species, a scientist can infer the presence of individuals associated with the tagged animal. Of the tags deployed so far for the Navy, the tags have operated for a period of 11.7 to 42 days, although tags have been known to operate for more than 100 days (see Section 3.5.2 for more information). Even if only one position is reported per day and a tag operates for a minimum amount of time, approximately 12 additional locations would be reported for that tagged individual with the cost of each "sighting" being about $417/sighting, if the more expensive tag is deployed. That is without taking into account the fact that the more expensive tags also collect dive data. However, the downside is that while the tags provide very useful data on animal movements and associations, they don't appear to yet provide the granularity required for behavioral response or calculation of RLs except in rare cases.

Acoustic Surveys

PAM in HRC is the most difficult monitoring method to quantify at this time. Some of the difficulty is due to the nature of the data and the medium and some is due to the logistics of contracting acoustic monitoring. There are three components to acoustic monitoring which contribute to the overall cost: the PAM devices, placing and retrieving the devices, and data analysis. Conceivably all three parts can be addressed by different service providers and the Navy has purchased these elements separately and in combination for various projects. In some cases, such the reports from the HIMB and NMFS summarized in Section 3.4.2, the Navy has paid for analysis of historical recordings and not been involved in the first two components of PAM. In the case of the PMRF instrumented range, the infrastructure is free to the monitoring program; however, funds are provided for recording and analysis. Aside from some towed array data collection that occurred in conjunction with vessel surveys (Boxes 1 and 11), focused PAM in HRC did not start in earnest until the first devices were placed near the Puuloa UNDET range and near Niihau during RIMPAC 2010 (Boxes 24 and 28). Although the recordings from Niihau have been analyzed, limited information was obtained from these recordings (see Section 3.4.1 and Box 28 summary). Other analyses are in process or are awaiting scheduling. Until standard methods for analysis and reporting can be developed, applied, and satisfactory reports generated, the acoustic monitoring component of monitoring in HRC will need to wait for cost-benefit analysis.

5.2.2 RESULTS AND COST BY MONITORING QUESTION

In general, it is the Navy's opinion that considering the cost per question is perhaps a less useful metric than the other metrics of cost and associated benefits described in great detail above. This conclusion is made for several reasons: (a) costs are necessarily a sum total of entire classes of methodologies, even where these methodologies may answer more than one of the five available questions; (b) the analysis of costs per question is less relevant for informing the planning of future monitoring without a consideration of the benefit gained from the attempts; (c) AMR and strategic planning process are guiding future iterations of the HRC monitoring plan away from the existing five questions, as described in Section 6. In that context, estimated costs for each of the five study questions are given below.

The five monitoring questions are:

1. Are marine mammals and sea turtles exposed to mid-frequency active sonar (MFAS), especially at levels associated with adverse effects (i.e., based on NMFS' criteria for behavioral harassment, TTS, or PTS)? If so, at what levels are they exposed?

Overall there exist two broad methodologies for approaching this question: (1) density estimates of each species as proxies for estimating exposure, and (2) actual observations of exposure collected during exercises, using either visual or acoustic methods. The LOE protocol utilizing MMOs on gray ships conducting exercises provides some data on animals observed while MFAS is active on the observational platform. Vessel surveys using a dedicated survey platform were attempted (Box 29), but the conclusion was made that it was prohibitively difficult to place such platform in the vicinity of Navy exercises. Finally, using sightings validated by the MMO methodology or the aerial surveys that orbit the Navy gray ships during exercises has produced estimates of RL for some animals during exercises on BARSTUR/BSURE at PMRF. Therefore, the costs associated with this question would be the sum of the MMO embarks on Navy vessels, aerial orbital surveys, range monitoring, and the vessel cruise to support a training event in November 2010 (Box 29).

2. If marine mammals and sea turtles are exposed to MFAS in SOCAL, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last?

As described in Section 3.7, the HRC visual survey Atlas effort concluded that redistribution was largely not answerable given only data from the visual surveys conducted thus far in HRC. The protocols of these surveys are different from one another, the areas and times surveyed are not necessarily suited for time series of redistribution, and areas adjacent to Navy activity (e.g., adjacent to BARSTUR/BSURE) have in some cases been rarely surveyed or not at all. This question could be addressed in the future with more systematically planned surveys in time and space, as well as by using PAM analysis. For example, the difference in the presence of various species detected by the PAMs at Niihau and Kaula Islet could be studied. Since these locations are immediately adjacent to, but off the PMRF instrumented ranges, patterns of presence and absence could be compared for times during the presence and absence of Navy exercise activity. Such an acoustic analysis is being considered for fifth and/or sixth year monitoring. However, the current total cost expended is $0, unless the costs of deploying these PAMs, as well as the analyses of their data that have already been contracted but not yet completed, are considered.

Comparison of animal movements from satellite tag data with Navy training events at PMRF range is also underway. With the fidelity of satellite tags, it may be possible to correlate gross animal movements with relation to use of MFAS (Appendix C).

The best method to answer this question may be analysis of the 10 years of acoustic data archived from PMRF. Recordings began in 2002 on a periodic basis, increased in 2006 to 2 days per month, and increased again in 2011 to 2 days per month plus before, during, and after certain training events (e.g., SCC). The analysis of this archived acoustic data has been on hold pending more efficient automated data classifiers; however, it could likely be used to provide a seasonal index of abundance on the range.

3. If marine mammals and sea turtles are exposed to MFAS, what are their behavioral responses to various levels?

For short-term behavioral responses, the only possible method to gather data is to obtain data during the approach of marine species to Navy assets during training exercises. The methodologies that might observe acute responses are focal follow from an aerial platform, MMO embarked on gray ship involved in a Navy exercise, M3R, and tags such as DTAGs. Thus, no unusual acute responses have been observed in HRC by MMOs embarked on gray ships, and statistical power is too low for the focal-follow aerial methodology, as described in Appendix B, due to infrequency of MFAS deployment coinciding with the small number of sightings. The relatively lower sighting rate of the orbital aerial methodology has been described in Section 3.3. Additionally, the HRC monitoring program is currently in the process of applying lessons-learned in focal follow aerial monitoring in the SOCAL to improve usability of videography obtained from the aerial platform during the methodology of orbiting a Navy ship at sufficient resolution to conduct subsequent behavioral analyses of the collected video. Therefore, only M3R is starting the first step of behavioral response, which is estimating RL first. Thus far there is one case that might suggest a behavioral response, an acoustic one, from humpback whales after MFAS exposure (Martin and Manzano-Roth 2012). Although this result is the only clear data point, costs associated with this question must be considered to be the sum of all methods: MMO embarks, aerial orbital methodology, and M3R. Additionally, the costs of satellite tagging might be added, as the HRC monitoring program is currently performing an analysis of satellite tagged animals on the Navy ranges during exercises to estimate RL, and possible behavioral responses inferred from the tag tracks (Appendix C). Note that since the estimation or measurement of RL is primarily associated with question 1, the question of costs is confounded with that question.

4. What are the behavioral responses of marine mammals and sea turtles that are exposed to explosives at specific levels?

Sightings of animals during monitoring for explosives exercises have been very few. None were observed during any SINKEX monitoring. Because UNDET monitoring occurs only in the mitigation zone, the few sightings that were made initiated waiting periods until the animal was not seen again or was observed to leave the mitigation zone. Therefore, by design of the current mitigations in the LOA, data on acute exposure-response is not collected. However, there have been two cases where animals were observed in between UNDET events. In one, a group of spinner dolphins was observed outside the mitigation zone, moved through the mitigation zone, and then continued traveling in the same direction (Department of the Navy 2009; see Section 3.6.1). In the other, a Hawaiian monk seal was observed swallowing a large bottomfish after one detonation but before another. In both cases it is unknown if the animals were attracted to the area by a previous detonation. One additional spinner dolphin sighting occurred, but after the event on the way back to port. This group was observed traveling along the coastline in the direction of the Puuloa range. If this methodology is considered unrelated to this study question, the cost expended is $0. If relevant, then the cost is the sum of all UNDET and SINKEX monitoring.

5. Is the Navy's suite of mitigation measures for MFAS and explosives (e.g., PMAP, major exercise measures agreed to by the Navy through permitting) effective at avoiding TTS, injury, and mortality of marine mammals and sea turtles?

The methods this question is addressing are: (a) LOE Study with MMOs embarked on Navy gray ships during exercises, (b) shoreline aerial surveys searching for stranded animals, and (c) explosives monitoring. Therefore, the costs associated with this question are a sum of these methodologies. Note also that although injured or dead animals have not been observed in HRC using these monitoring methodologies, the gathered data only represents absence of evidence of impacts.

5.3 LESSONS LEARNED

The diversity and evolution of HRC monitoring projects has greatly expanded the knowledge base for marine species, monitoring methods, and data management for the Navy, the public, and the scientific community. While much of the new scientific knowledge gained from monitoring has been described elsewhere in this document, in peer-reviewed publications, and in the many reports that support the annual monitoring reports (Department of the Navy 2009b, 2010b, 2011b, 2012b), a selection of the most salient lessons learned about Navy monitoring in HRC are stated below. Lessons learned have been discussed annually with NMFS and have been incorporated into each iteration of the HRC annual monitoring plan (Department of the Navy 2009a, 2010ba, 2011a, 2012a). The full extent of the lessons are still being discovered and evaluated as the program evolves through experience, guidance, and advances in our understanding. The lessons learned (some of which are succinctly described here) are major components in shaping the developing monitoring program.

1. Different modes or methods of monitoring are optimized for characterizing the marine species in the environment at different scales.

Generally speaking, four different "platforms" have been used to collect monitoring data in HRC: aircraft, surface vessels, animal tags, and PAM. There is a separate timeline for each of these platforms in the visual timeline in Section 3.2. By examining the various monitoring projects on each timeline, it is evident that several different methodologies of data collection have been used for each platform. Therefore, even within one monitoring platform, specific choices of available methodologies have the effect of optimizing the characterization of marine species in the environment at different scales of both time and space. The choice of platform and methodology can thereby optimize the applicability of the data obtained to meet the goal of answering monitoring questions.

For example, aerial surveys have been used for systematic survey patterns, shoreline surveys, and elliptical orbits near a Navy vessel. The cost-benefit results from Section 5.2.1 indicates that marine species are observed using all three survey patterns, but at different rates of detection, and even different types of marine species are seen. Systematic survey patterns can sample the distribution of many species across a large area of the environment (Buckland et al. 2001), but they cannot reveal patterns of species presence at any particular location over time, unless the same pattern is repeated frequently at short time intervals—something that has not been appropriate for Navy monitoring, because the timing of monitoring is linked to Navy training schedules instead of regular sampling intervals.

Systematic survey patterns in the open ocean are also not particularly effective in HRC for sighting sea turtles. Coastline surveys, on the other hand, are an efficient method for sampling species that aggregate in the shallow water near the coast; in Hawaii, this is a good method for assessing monk seals on beaches and sea turtles, particularly in areas with sandy bottoms. Thus, these surveys have resulted in the sampling of marine species that are seen less frequently when using other visual survey methodologies. The aerial coastline methodology has traditionally been viewed as the only field method to assess whether animals are stranding on remote shorelines; however, ground-based coastline surveys are scheduled for 2013 to evaluate alternative methods. The cost-benefit results clearly indicate that for observing these species in this small part of the environment, aerial surveys are less costly per sighting than for other methods.

The other platforms have similar considerations. Surface vessels can be used to monitor very small areas for changes in marine species presence over short periods of time. For example, UNDET monitoring is comprised of repetitive visual searches largely within the mitigation zone of explosives training (~1.5 square kilometers) over a span of only a few hours. During this type of monitoring marine species have been observed to come and go in periods of time shorter than an hour (e.g., Department of the Navy 2009, Uyeyama et al. 2012).

Data from tags have different levels of temporal and spatial resolution. To date, the Navy has used satellite tags that impart locations of species when they are at the surface of the water and, in some cases, collect the details of dive depth. However, the data can be relatively coarse, especially if a deep-diving animal's location is known only when it is at the surface. Tags exist that collect more variables and that record more fine-scale data, but they are relatively limited in the time they can sample because the data storage capacity required to retain detailed movement data within the tag hardware is combined with a suction cup application that often results in less durable attachment (e.g., several hours–3 days). Therefore, this is another example of two "modes" of tags that can provide marine species movement data at different spatial and time scales. To date, HRC monitoring has almost entirely utilized tags that address occurrence and distribution of marine species rather than detailed, short-term behavioral data that can be used to assess behavioral response.

The Navy is especially fortunate in the HRC to be able to use passive acoustic monitoring on several spatial scales. The PMRF instrumented range on Kauai allows monitoring of sounds in the environment over hundreds of square miles. When the M3R system was installed in 2011, it provided the additional research potential for a vocalizing marine mammal to be localized in near-real time and localized within the area of the range. While the system is dependent on species and vocalization/echolocation call characteristics and does not work for or differentiate between all mammal species, it has proven to be an important research and monitoring tool. The M3R system has unified the large scales of time and distance to provide a synoptic view of PMRF. Even so, the HRC is much larger than PMRF, so the Navy has collected or obtained analysis of PAM recordings from a number of autonomous buoys at different locations in the MHI. These buoys are limited to the location that they are placed and the distance at which they can detect sounds; however, they can record for long periods of time and therefore effectively monitor for large portions of the year at specific locations. This data collection provides information on marine presence at different time scales from diel to seasonal.

The above examples of monitoring methods and platforms collecting data at different spatial and time scales may seem obvious, but this lesson is an important consideration for designing an effective monitoring program. Since the program in the HRC is relatively new, the Navy has focused a great deal on collecting data that characterizes large scale patterns of marine species occurrence. This is an appropriate scale to focus on at this time. Although at some areas where the Navy trains regularly, such as PMRF, monitoring efforts are moving toward a focus on finer scale distributions, movements, and behaviors of marine species, much more information remains to be collected at larger scales before characterization of the species in the environment can move away from learning about occurrence.

2. The best source for ship position and sonar data is from data collected by Range Operations at PMRF.

Identifying behavioral response during actual training events requires data on the position of Navy vessels and sonar use. On board the vessels themselves, sonar usage is captured through the Sonar Positional Reporting System (SPORTS). Ongoing monitoring studies in HRC have determined that data collected through SPORTS is generally too coarse for applicability to monitoring studies and not conducive to a behavioral response analysis. However, the ship positions and recordings from the underwater hydrophone arrays at PMRF are of much higher granularity. A comparison on ship position between SPORTS and PMRF position data demonstrated that the temporal granularity of PMRF position data was an approximately two to four orders of magnitude greater than SPORTS. SPORTS also does not provide the time of each sonar ping, which is important for estimating RLs. For training events not occurring on the PMRF range, exercise re-creations can in some cases be generated for ship position and sonar, but these have been found to be time-consuming, inexact, and cost-prohibitive.

3. Non-random search patterns assisted by other monitoring methods can be effective at locating marine species.

The Navy's experience while monitoring in the HRC has demonstrated clearly that when a methodology that can localize marine species in near-real time is combined with the deployment of visual platforms that are able to place themselves in likely locations where marine species might be localized, sighting rates can be increased. The M3R system has been demonstrated to be particularly successful at directing vessel visual surveys to locations of marine species (boxes 39 and 41, 47–49, and 53 and 54). 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, a large survey vessel working with M3R was able to verify species that are typically challenging to observe, including a Blainville's beaked whale and sperm whale. Other, somewhat more nominal benefits, have been experienced from accompanying tagging vessels with larger sighting vessels (boxes 34 and 35, 48 and 49) and aerial surveys (boxes 35 and 36). Additionally these sightings, by definition, provide visual verifications to acoustic detections, thereby facilitating the critical development of better algorithms for acoustic classification and detection of marine species.

4. New scientific questions

The five original monitoring questions were found to be too difficult to achieve upon review by the Scientific Advisory Group (SAG). Some of what has been learned from marine species monitoring in HRC is that more refined scientific questions emerge as patterns from observations are considered. These refinements to questions are exceptionally useful to the Navy's monitoring program, because revised scientific questions will serve as the new metric that the monitoring program is moving toward (see Section 6.1.2.1). Achievable and meaningful scientific questions provide purpose and focus for monitoring activities and are more likely to result in the funding of methodologies that lead to results that contribute to measurable progress in answering overarching monitoring questions. The lessons learned from monitoring in HRC through 2012 have provided useful experiences from which to make refinements to enhance relevance to Navy monitoring.

Some study questions that emerge as a result of considering the monitoring results are:

- Why are some species observed more regularly during monitoring at PMRF while others are not observed, relative to other parts of the HRC? Is it a factor of environmental conditions or search methodologies, or is there something unusual about the distribution of this species around Kauai and Niihau? Is this related to the existence of PMRF and Navy training in that area? Are the same patterns seen near other areas of human activity, such as the south shore of Oahu?
- Is there a seasonal pattern to pilot whale presence near PMRF? Based on a small number of sightings, preliminary data suggests more sightings in winter than summer. Is this pattern real or a result of a small sample size?
- Is there an unusual concentration of rough-toothed dolphins on PMRF? Tag and sighting data show many more sightings and locations on the range, than off the range.
- Is there a resident population of spinner dolphins around Kaula Island? Do they use other nearby habitat regularly?
- Is there a resident population of bottlenose dolphins around Kaula Island? Do they use other nearby habitat regularly?
- Are there individual monk seals that haul out at Kaula Island on a regular basis? Do these individuals haul out at Niihau, Kauai, or other islands? Is the presence of these individuals being counted by existing population surveys?
- How much do the populations of false killer whales around the Hawaiian Islands use the area near PMRF? What is the significance of the area near PMRF in relation to the rest of the range of each population?
- What is the seasonal pattern of acoustic detections of minke whales near the Hawaiian Islands?
- Is there a pattern of increasing humpback whale presence around Kauai and Niihau in the winter?

In conclusion, the lessons discussed here, aside from the new scientific questions, are general in nature, but that is not surprising. As a formal integrated monitoring program, marine species monitoring has been occurring for less than 5 years. Much is needed to be learned about the logistics of monitoring around assets that are conducting Navy training, as there exists a steep learning curve of its own that is complex and unique to monitoring for the Navy. As logistical challenges are progressively overcome, the Navy can better apply scientific lessons learned. The knowledge gained is expected to improve the monitoring program and increase the quality and relevance of results.

6 FUTURE DIRECTIONS

The future direction for marine species monitoring will be based on experience which has been gained through the 4 years of monitoring in HRC as well as multiple levels of guidance. The ICMP (Section 1.1), Adaptive Management (Section 6.1.1), the SAG report (Section 6.1.2) establish goals, provide a process for refinement and evolution, and provide guidance for the overall U.S. Navy Marine Species Monitoring Program through the Strategic Planning Process described below. Additionally, two HRC-specific documents have been generated which will be utilized as practical decision tools: the regional SAG input matrix (Section 6.1.2.1), and the Retrospective Data Analysis Scientific Workgroup Report (6.1.3). All are described in more detail below and followed by a discussion of how this guidance has already been utilized in the final year monitoring in HRC (Section 6.2).

6.1 Revision to Compliance Monitoring Structure

A 2010 U.S. Navy-sponsored monitoring meeting in Arlington, Virginia initiated a process to critically evaluate the current U.S. Navy monitoring plans and begin development of revisions to existing range-specific monitoring plans and associated updates to the ICMP. Discussions at that meeting, and at the U.S. Navy/NMFS annual AMR meeting and through the Navy/NMFS adaptive management process, established a way ahead for continued refinement of the U.S. Navy's monitoring program. This process included establishing a SAG composed of technical experts to provide objective scientific guidance for Navy consideration. The Strategic Plan was intended to be a primary component of the ICMP and to provide a "vision" for U.S. Navy monitoring across geographic regions, serving as guidance for determining how to most efficiently process and effectively invest the marine species monitoring resources to address ICMP top-level goals and to satisfy MMPA (LOA) regulatory requirements. The objectives of the Strategic Plan, and its more recent incarnation as the Strategic Planning Process, is to continue the evolution of U.S. Navy marine species monitoring toward a single integrated program, incorporating expert review and recommendations, and establishing a more transparent framework for soliciting, evaluating, and implementing monitoring investments across the U.S. Navy Range Complexes and study areas.

The Strategic Planning Process has five major implementation steps:

1. Identify overarching intermediate scientific objectives
2. Develop individual monitoring project concepts
3. Evaluate, prioritize, and select monitoring projects
4. Execute selected monitoring projects
5. Report and evaluate progress and results

These steps serve three primary purposes: (1) to facilitate the U.S. Navy in developing specific projects addressing one or more intermediate scientific objectives; (2) to establish a more structured and collaborative framework for developing, evaluating, and selecting monitoring projects across all areas where the U.S. Navy conducts training and testing activities; and (3) to maximize the opportunity for input and involvement across the research community, academia, and industry.

Furthermore, this process is being designed to integrate various elements including:

- Integrated Comprehensive Monitoring Program top-level goals
- Scientific Advisory Group recommendations
- Integration of regional scientific expert input
- Ongoing adaptive management review dialog between NMFS and Navy
- Lessons learned from past and future monitoring at Navy training and testing ranges
- Leveraged research and lessons learned from other Navy funded marine science programs

The Strategic Planning Process is currently being developed in coordination with input from NMFS Headquarters. Along with the ICMP, it clearly identifies the goals and objectives of the Navy monitoring program, presents the guidance and expert review that will be used to direct efforts, and defines the process for evaluating and selecting how the U.S. Navy's marine species monitoring program budget is invested. It is anticipated that some current monitoring efforts will continue to be similar to past practices, but the level of effort and investment may be allocated differently across U.S. Navy ranges.

For the monitoring program in the HRC, two further planning and analysis efforts followed as a logical extension of the SAG recommendations and have contributed to the on-going development of the Strategic Planning Process. Together these efforts were guided by comments from NMFS at the annual 2011 AMR meeting indicating that it would be desirable that the decision-making process for choosing monitoring methodologies be more transparent. First, a regional SAG (rSAG) was convened to focus the SAG process and conceptual framework solely on the HRC. Second, a similar group of scientists, known as the Scientific Workgroup, was convened to evaluate study questions which could be retrospectively asked or answered using the corpus of all available monitoring data gathered in the HRC and to highlight lessons learned to be used for planning future monitoring.

6.1.1 ADAPTIVE MANAGEMENT

The current Navy Fleet monitoring program is composed of a collection of "range-specific" monitoring plans; each was developed individually as part of the MMPA/ESA authorization processes. These individual plans establish specific monitoring requirements for each range complex based on a set of effort-based metrics (e.g., 20 days of aerial survey). Concurrent with implementation of the initial range-specific monitoring plans, the Navy and NMFS began development of the ICMP, as described in Section 1.1. Part of the agreed-upon process of monitoring was that the NMFS and the Navy would meet yearly to discuss results and progress from monitoring. Upcoming monitoring requirements would be adapted to meet gaps in knowledge of marine species on Navy ranges or emergent issues. Some other meetings that were required under the LOAs for monitoring were built into the schedule to provide Navy feedback and input from scientific and public parties on Navy marine species monitoring.

As stated above in Section 6.1, the October 2010 Navy monitoring meeting initiated a critical evaluation of Navy monitoring plans and began development of revisions to existing range-specific monitoring plans and associated updates to the ICMP. This process included the establishment of the SAG which convened in March 2011. The focus of the SAG was evaluation of current Navy monitoring approaches under the ICMP and existing LOAs and development of objective scientific recommendations that would serve as a basis for a Strategic Planning Process which would be incorporated as a major component of the ICMP. Composed of leading academic and civilian scientists with significant expertise in marine species monitoring, acoustics, ecology, and modeling, the group produced a consensus report which laid out over-arching and range-specific recommendations for the Navy's Marine Species Monitoring program and is described in Section 6.1.2.

Further AMR meetings in October 2011 and October 2012 between the Navy and NMFS have continued to refine the Navy's monitoring program. Consensus has been that the ICMP, in conjunction with annual AMR review, and the strategic planning process, would continue the evolution of Navy marine species monitoring towards a single integrated program. The Navy wide monitoring program will incorporate SAG recommendations when appropriate and logistically feasible, and establish a more collaborative framework for evaluating, selecting, and implementing future monitoring across the all Navy range complexes through AMR and Strategic Planning Process.

6.1.1.1 Revision of Monitoring Questions

Based on discussions between the Navy and NMFS, future monitoring would address the ICMP top-level goals through a collection of specific regional and ocean basin studies based on scientific objectives. Quantitative metrics of monitoring effort (e.g., 20 days of aerial survey) would not be a specific requirement, but instead the requirement on the monitoring program would be to pose and make progress toward answering scientific monitoring questions. This approach is already beginning to be implemented in the current year Mariana Islands Range Complex (MIRC) monitoring plan.

The AMR process and reporting requirements would serve as the basis for evaluating performance and compliance. In light of no longer evaluating the Navy's monitoring program via metrics of effort, the adaptive management process would make evaluations by considering the quality of the work and results produced, as manifested in the annual monitoring reports, as well as peer review and publications, and public dissemination of information, reports, and data. Such a process is fundamentally an extension of the goal of the original HRC monitoring plan (Department of the Navy 2008) of using the annual monitoring reports to inform adaptive management. The Strategic Planning process would be used to set intermediate scientific objectives, identify potential species of interest at a regional scale, and evaluate and select specific monitoring projects to fund or continue supporting for a given fiscal year. The Strategic Planning Process would also address relative investments to different range complexes based on goals across all range complexes, and monitoring would leverage multiple techniques for data acquisition and analysis whenever possible.

6.1.2 Scientific Advisory Group Recommendation

The SAG developed a framework for evaluating all Navy range complexes under the ICMP and for formulating objective, expert scientific recommendations for addressing top-level goals of the ICMP. The recommendations were at multiple conceptual levels from broad to specific:

- Broad level concepts which defined a continuum of knowledge in which monitoring objectives could be placed in context

- Mid-level recommendations on practical program structure and management which could be implemented at the overall Navy-wide program level but also at the range complex level
- Range-specific recommendations which were based on an assessment of our understanding of marine species at each range complex along the continuum of knowledge and provided specific guidance for monitoring approaches

In this section, the broad and mid-level recommendations are summarized because of the relevance to practical decisions made for HRC monitoring as well as the range-specific recommendations.

Fundamental Considerations and Conceptual Framework. The SAG recommended recasting the original five questions into a conceptual framework of occurrence, exposure, response, and consequence. Occurrence represents basic or baseline information on presence and diversity of species that occur on a Navy range, but also includes patterns of habitat use, population structure, density and abundance, and elements of behavioral ecology. Exposure represents information on Navy training activities in order to allow determination of RLs and other metrics of interest. When combined with occurrence information, it is possible to improve the estimated exposures to Navy sounds sources. Response incorporates how animals react over multiple time scales. If animals respond in a way that reduces exposures, this can be used to refine exposure estimates. And finally, consequence represents the long-term impacts of exposures and responses, including cumulative impacts to fitness.

SAG Recommendations for Program Structure and Management. Programmatic recommendations which have, in many cases, been considered and applied at the Navy-wide level are also relevant at the range complex level. The recommendations are applied through revisions to range complex monitoring plans and implementation "on the ground." These programmatic recommendations include:

- Increased transparency to, and collaboration with, the scientific community on how monitoring plans are developed, revised, and implemented
- Increased and consistent availability of data (classified and unclassified) as well as refinement of data standards
- A change of mindset for both Navy and NMFS away from evaluating the compliance monitoring program via metrics of effort and instead evaluating progress toward scientific objectives
- A focus on different ecological scales including individual, group and population
- Establishment of the time scales that monitoring studies at training events are intended to capture
- Collection of baseline occurrence and behavioral data when required
- Expansion of acoustic exposure metrics beyond RL
- Ensure access to all required data required for analysis
- Moving away from planning for retrospective data analysis and instead utilizing prospective experimental design with sufficient statistical power based on objectives identified by the strategic planning process and the upcoming change to study-question-based range complex monitoring plans

- Conduct an assessment of existing data sets to ensure that they are utilized to the full extent practicable
- Incorporation of existing data from the effects of sonar into a meta-analysis as data sets become sufficiently mature to support such analyses
- Conduct annual science review meetings and convene an interdisciplinary working group on PAM and how to best focus on response to sonar activities
- Collaboration with NOAA whenever possible
- Focus on explosives and low frequency active sonar in addition to MFAS

SAG Range Specific Recommendations. HRC was rated medium in the need for gathering more data for basic occurrence questions and high in the need and for addressing exposure and response questions, due to the presence of an instrumented range at PMRF. Ability to address consequence questions was rated medium; however, these questions are typically considered quite long term and require substantial understanding of occurrence, exposure, and response. Continuation of a broad suite of monitoring techniques was recommended including passive acoustic monitoring, non-systematic surveys incorporating tagging and photo-identification studies with the addition of biopsy. Data gaps, a high level of Navy activity, and the existence of the fixed hydrophone array at PMRF, elevated the priority of the Kauai and Niihau region in the recommendations. It was recommended that aerial surveys be conducted only if it is mission-critical and the data cannot be collected in a safer way, due to the safety risk and potential for low return on investment. Several aerial techniques have been utilized in HRC and should be assessed individually.

For information on elements of the SAG recommendations which have been incorporated into the HRC monitoring program, see Section 6.2. The full SAG report is available through the Navy's Marine Species Monitoring web portal at the link listed in Section 1.4.

6.1.2.1 Regional Scientific Advisory Group

In June 2011, following receipt of the SAG report, the Navy solicited input from researchers at local universities, science centers and private institutions with research experience in Hawaii. Contributors had expertise across disciplines, species, and techniques and had publications relevant to marine species monitoring in the Navy's HRC. No Navy funding or obligation of Navy funding was associated with participation. After input was collected, the Navy organized the information into a preliminary matrix of questions. This step was initiated in order to determine what the local scientific community recommends as highest priorities for Navy-funded marine species monitoring. The information was then organized into a matrix which shows how HRC-specific questions can be elevated and generalized to apply to a larger Navy-wide monitoring plan (Table 6.1-1). This step was intended as a practical decision tool for selection of the most relevant monitoring questions in HRC. Additional input for other HRC marine mammal issues may still be considered for future inclusion given scientific merit, prioritization of monitoring, logistic feasibility, and funding needed. Currently, this process is undergoing internal Navy review prior to future discussions with the NMFS via AMR and the Strategic Planning Process.

For monitoring in HRC for FY 2013, a question from this matrix was selected as the focus of a project. That question is, "What are the spatial movement patterns and habitat use (e.g., island-associated or open-ocean, restricted ranges vs. large ranges) of species that are exposed to MFA sonar and how do these patterns influence exposure and potentially responses?" For more information on this, see Section 6.2 Final Year Compliance Monitoring (October 2012 to October 2013).

Table 6.1-1: Matrix of Input from rSAG in the Context of Potential Application to a Larger Navy-Wide Plan

Overarching Question (could be applied across Navy ranges)	Questions Submitted by rSAG to Apply to HRC	HRC-Relevant Specifics	Field Techniques	What part of the conceptual framework does this address?
Are there areas of high cetacean occurrence on Navy Range complexes?	Are there hotspots of cetacean occurrence in the HRC?	***Note:*** PAM recordings that already exist for HRC should be analyzed	PAM, small-vessel surveys, ocean glider surveys, satellite tagging	Occurrence
What populations of marine mammals are exposed to MFAS sonar?	Are there multiple genetically isolated populations (e.g., island-associated and offshore, or multiple island-associated) of species that may be exposed to MFAS sonar?	***Focal location:*** Kauai - PMRF, Oahu - Pearl Harbor and Puuloa Underwater Range ***Species:*** dwarf and pygmy sperm whales, beaked whales, melon-headed whales, pygmy killer whales, false killer whales, and short-finned pilot whales	Photo-identification, biopsy sampling	Occurrence, Exposure
	Is there finer-scale population structure for some species present in HRC?		Photo-identification, biopsy sampling, tagging	Occurrence
	What is the species occurrence and distribution within the HRC and how does this change in response to Navy activities?	***Focal location:*** Kauai - PMRF ***Note:*** Apply species identification algorithms to archived acoustic data for HRC	Concurrent visual /acoustic surveys before, during and after naval exercises (include photo-identification, biopsy sampling, and satellite tagging) Use Navy instrumented ranges and validate species identification and occurrence estimation methods with surface based visual/acoustic surveys & tagging	Occurrence, Exposure, Response
What are habitat use and movement patterns of	What are the spatial movement patterns and habitat use (e.g., island-associated or open-ocean, restricted ranges vs. large	***Focal location:*** Kauai - PMRF, Oahu - Pearl Harbor and Puuloa Underwater Range, north of	Multi-area photo-identification, satellite tags	Occurrence, Exposure

Overarching Question (could be applied across Navy ranges)	**Questions Submitted by rSAG to Apply to HRC**	**HRC-Relevant Specifics**	**Field Techniques**	**What part of the conceptual framework does this address?**
marine mammals and sea turtles in areas where the Navy trains with MFAS and underwater explosives?	ranges) of species that are exposed to MFAS sonar and how do these patterns influence exposure and potentially responses?	Perret and Jagger Seamounts Need to address variability during training, seasonal, interannual		
(Same question can be asked how different age or sex classes or different populations of same species respond.)	How do different species differ in spatial responses (e.g., horizontal or vertical movements) to exposure to MFAS over periods of days to weeks?		Multi-area photo-identification, satellite tags	Occurrence, Exposure
	Are there differences in occurrence/abundance/spatial use between areas with high Navy activity (e.g., Kauai) and low Navy activity (Lanai, Hawaii), and what factors may be responsible for such differences?	***Focal locations:*** high use: Kauai - PMRF, Oahu - Pearl Harbor and Puuloa Underwater Range; low use: Lanai, Maui, Kahoolawe, east and south of Big Island	Multi-area photo-identification, satellite tags	Occurrence, Exposure
	What is the response of beaked whales, melon-headed whales, and false killer whales to MFAS exercises in PMRF training range?	***Focal location:*** Kauai – PMRF ***Species:*** beaked whales, melon-headed whales**,** and false killer whales	PAM; cabled hydrophones; satellite tagging; BRS	Occurrence, Exposure, Response
	What is the species occurrence and distribution within the HRC and how does this change in response to Navy activities?	***Focal location:*** Kauai – PMRF ***Note:*** Apply species identification algorithms to archived acoustic data for HRC	Concurrent visual/acoustic surveys before, during and after naval exercises (include photo-identification, biopsy sampling, and satellite tagging) Use Navy instrumented ranges and validate species identification and occurrence estimation methods with surface based visual/acoustic surveys & tagging	Occurrence, Exposure, Response

Overarching Question (could be applied across Navy ranges)	Questions Submitted by rSAG to Apply to HRC	HRC-Relevant Specifics	Field Techniques	What part of the conceptual framework does this address?
	How many animals of how many species frequent the waters around the Hawaiian Islands and how do their numbers change by season?		Aerial surveys, PAM, satellite tagging, aerial sonobuoy surveys	Occurrence
What are the trends in abundance of species that are regularly exposed to MFAS?		***Focal location:*** Kauai - PMRF	Multi-year mark-recapture, combined with genetic sampling to confirm population identity	Exposure, Response, Consequences
What is the density of marine mammals and sea turtles on and near Navy ranges?	What is the density of cetaceans most commonly present in PMRF?	***Focal location:*** Kauai - PMRF (instrumented range)	PAM; vessel surveys; array recordings, cabled hydrophones	Occurrence
What are the best automated methods for acoustically detecting and classifying marine mammals on Navy ranges? ***Note:*** These tools must be location-specific as there is geographic variation in the vocalizations produced by many cetacean species	What are the best methods for the automated acoustic detection and identification of important species such as beaked whales, dwarf sperm whales and false killer whales and melon-headed whales?	***Species:*** beaked whales, dwarf and pygmy sperm whales, melon-headed whales and false killer whales	Development, validation, and evaluation of various automated methods for detection and classification (conducted by species/populations)	Occurrence
Is there a behavioral response by marine mammal	What is the response of beaked whales, melon-headed whales, and false killer whales to MFAS exercises in PMRF training	***Focal location:*** Kauai - PMRF (instrumented range) ***Species:*** beaked whales, melon-	PAM; cabled hydrophones; satellite tagging; BRS	Exposure, Response

Overarching Question (could be applied across Navy ranges)	Questions Submitted by rSAG to Apply to HRC	HRC-Relevant Specifics	Field Techniques	What part of the conceptual framework does this address?
species to MFAS or underwater explosions?	range?	headed whales and false killer whales		
	Does behavior change with sound exposure?		Satellite tagging; BRS	Exposure, Response
Can species that occur on Navy ranges perceive Navy sound sources?	How do the various species hearing audiograms differ? Do they differ as much as the beaked whale, the bottlenose dolphin, and the whitebeaked dolphin? Can perceived sound pressure levels be predicted from knowing source level, propagation loss, and hearing threshold?		Evoked potential audiometry	Exposure, Response
Do marine mammals stranding after exposure to sonar suffer hearing loss as compared to those stranding independent of sonar exposure?			Evoked potential audiometry	Exposure, Response, Consequences
Do marine mammals and sea turtles near explosions suffer profound hearing damage?		***Focal location:*** Kauai - Puuloa UNDET range ***Species:*** sea turtles	Evoked potential audiometry	Exposure, Response, Consequences

Notes: BRS = Behavioral Response Study, HRC = Hawaii Range Complex, MFAS = mid-frequency active sonar, PAM = passive acoustic monitoring, PMRF = Pacific Missile Range Facility, rSAG = Regional Scientific Advisory Group

6.1.3 Retrospective Data Analysis Scientific Workgroup

Marine species monitoring in the HRC has produced numerous data sets which have been collected to meet diverse goals and subsequently have used diverse methodologies and platforms (see Section 3). In addition to analyses of aerial focal follows, satellite tags, and passive acoustic data (primarily from PMRF) in the presence of MFAS which are intended to ascertain if there is a behavioral response to MFAS during actual training events, an expert working group was convened in order to recommend hypothesis-based questions and strategies which are relevant and answerable through retrospectively mining the existing Fleet-funded data sets, supported with the use of other data sets (such as those funded by OPNAV N45/LMR, etc.), and to assess the entire body of data comprehensively. The working group was asked to assess if any of the original five monitoring study questions could be answered through this process and, if not, to recommend specific new questions which could be prioritized, analyzed, and reported in the regulatory timeline. The working group generated a report (Appendix C) which will be used as a practical decision tool for immediate analysis projects and also for future monitoring methods and analysis.

The working group's report expanded upon the SAG Report (2011) which suggested recasting the original five study questions into a conceptual framework of occurrence, exposure, response, and consequences. The working group captured the original five study questions while also applying the recommendations of the SAG through further refining the conceptual framework for more specificity which led to a table of 12 questions. The questions were hypothesis-based and reviewed according to the current status of knowledge relative to the questions, the ability to answer using only existing data sets, the perceived overall importance, and short-term answerability (to align with regulatory reporting deadlines). The working group was then asked to rank the questions according to their answerability over various time scales and within an existing budget. The questions which were ranked as answerable within the short-term (6 months) are as follows:

1. How well is baseline occurrence (distribution, density, and habitat use) known/defined (short-medium term) across species/species groups?

Existing PAM, tagging/tracking, aerial survey, and vessel survey data can be used to address this question for certain species. This question has a high potential for short-term benefit because it provides baseline information on spatial overlap of species distributions with Navy training events. Future questions of exposure and potential impact are dependent upon this information.

2. How does our ability to address questions of exposure (integrating propagation models and animal occurrence) vary with species/species groups?

Existing PAM, tagging/tracking, aerial survey, and vessel survey data can be used to address this question by integrating species distribution data with patterns of sound transmission.

3. What are the short-term behavioral responses of marine mammals and sea turtles when exposed to MFAS/explosions at different levels/conditions?

Existing PAM, tagging/tracking, aerial survey, vessel survey, MMOs on Navy vessels, and active source data can be used to address this question by integrating behavioral data with information about MFAS and UNDETs.

An additional question was also ranked as short-term, high priority:

4. How well are U.S. Navy noise-generating activities known and available outside the classified realm?

In many cases monitoring in the HRC has overlapped with training events, but the ability to examine biological data with training event data is confounded by accessibility, due to classification of information. This question is highly relevant but requires internal Navy action and cannot be conducted by contractors alone.

Some components of the working group recommendations are not discussed in great detail in this section, such as future recommendations, and the relative importance of medium-term and long-term questions. This should not be interpreted as a dismissal of the information on the part of the Navy but rather an immediate focus on questions which are considered answerable in the short-term and are a priority for monitoring resources.

The working group provided recommendations for future monitoring activities, based on a unique perspective of specific lessons-learned from examination of existing data sets. Included is an assessment of the strengths and challenges of monitoring platforms, a qualitative assessment of the relative importance of questions and the anticipated time-scales, and a focus on coordination of multiple platforms in long-term data sets in order to improve our understanding of noise effects on marine species. Importantly, the working group provided an assessment of the relative contributions/relevance of specific monitoring systems along with order of magnitude estimates on level of effort and cost within the context of each question. This assessment provides guidance on an interdisciplinary approach to an integrated monitoring program in HRC, and proposed methods to answer questions which span the refined conceptual framework and multiple time scales.

6.2 Final Year Compliance Monitoring (October 2012 to October 2013)

The evolution of the HRC monitoring program has been, and continues to be, concurrent with the evolution of larger U.S. Navy Marine Species Monitoring Program. While systemic changes are in process, marine species monitoring in the HRC in FY 2013 demonstrates specific incremental changes which come as a result of the above processes, documents and practical experience. The specific implemented changes in HRC are representative of some of the anticipated future directions for the HRC monitoring program and are described below:

Divergence from effort-based metrics. The monitoring program is committed to advancing our knowledge of marine species on U.S. Navy range complexes by addressing the topics which are outlined in the ICMP. However, effort-based metrics, while easy to tally and report, have proven to be a limiting factor to the iterative process which is required of a monitoring program with scientific goals. Therefore, through the discussions with NMFS at AMR, an incremental divergence from effort-based metrics to question-based monitoring has been implemented in the HRC Monitoring Plan. In the 2011 HRC Monitoring Plan (found in the 2010 year-end report to NMFS) NMFS accepted changes in the passive acoustic monitoring metrics from deployment of four autonomous recording devices to a more flexible commitment for passive acoustics. This flexibility has manifested in the planned increased use of a unique asset in the HRC–the underwater hydrophone ranges at PMRF in FY 2013.

Recasting the original five study questions to a revised conceptual framework. Recommendations from the SAG report included a shift from the original five study questions in the ICMP to a new conceptual framework of knowledge which spans occurrence, exposure, response and consequences. It was also recommended that specific monitoring projects be results-focused and question-based, to facilitate results which are statistically significant. The process of requesting input from the rSAG required that all suggested monitoring questions align with recommendations from the SAG report and address the most appropriate category along the conceptual framework. One of the questions (question 2, below), proposed by a member of the rSAG, directly addresses occurrence and exposure (and potentially response).

A shift to question-based monitoring projects to facilitate generation of statistically powerful results. Two questions have been established and presented to the contractors for FY 2013 monitoring:

1. Do marine mammals strand along shorelines of the main Hawaiian Islands within one week following naval training events?

The main goal of this project is to fulfill visual survey effort metrics. However, the monitoring goal is to determine if strandings were going undetected because coastlines were too remote for strandings to be detected. In the past these surveys have occurred with the use of airplanes, and more ideally, helicopters. In FY 2013, the contractor proposed a combination of helicopter surveys along remote shorelines of Kauai and Niihau and a land based pilot survey of Niihau. Sightings (including monk seals) from the helicopter will be compared to sightings of the land-based survey team for effectiveness and cost.

2. What are the spatial movement patterns and habitat use (e.g., island-associated or open-ocean, restricted ranges vs. large ranges) of species that are exposed to MFAS and how do these patterns influence exposure and potentially response?

The main goal of this project is to fulfill visual survey, passive acoustic, and satellite tagging metrics. However, the monitoring goal is to further our understanding of the baseline occurrence, natural variation, and behavioral states of marine species at PMRF and in surrounding areas, exposure and potential responses of these species to MFAS.

Increased utilization of the hydrophone ranges at PMRF. There is strong justification for directing monitoring resources to use of the PMRF hydrophone arrays as one platform used in concert with other methods to address monitoring questions. Increased use of the underwater hydrophone array at PMRF was recommended in the SAG report because of the potential for acoustic monitoring and synergy with boat-based monitoring. Collaboration between teams monitoring hydrophone ranges (M3R) at AUTEC and SCORE and tagging teams is a proven methodology which has resulted in a substantial increase in our understanding of baseline movement and habitat use patterns and behavioral response to MFAS (Falcone et al. 2009, McCarthy et al. 2011, Tyack et al. 2011). The M3R team is able to, in some cases, use acoustic detections to localize animals and vector the tagging vessel to approximate animal locations on the range resulting in an increased likelihood of encounter, tag deployment, and visual verification of acoustic detections. Additionally, lessons learned from the Retrospective Data Analysis Scientific Workgroup reinforced that an excellent source of available ship position and sonar transmission data comes from PMRF ship positional data and hydrophone recordings, generating the most accurate and numerous estimated RLs. While a different team has been using the range phones for monitoring data collection since 2002, use of the PMRF hydrophone range in collaboration with a satellite tagging team began in 2011 when the M3R system was installed at PMRF. In FY 2013 HRC monitoring and two tagging projects will take place which are a collaboration between the M3R team from NUWC, SPAWAR, and a satellite tagging team.

In addition, in 2013, the M3R system was used to monitor the entire range for the presence of Blainville's beaked whales before, during, and after an SCC multi-ship sonar operation. These data will be analyzed to determine if large scale population movements similar to those documented at AUTEC are present (McCarthy et al., 2011, Moretti et al., 2010). These projects will occur before Navy training events to increase the likelihood of overlap between data on animal presence, movement and diving in the presence of active sonar transmissions. This project design cannot guarantee that animal movements will overlap with a Navy-generated sound field in a way that will be meaningful for behavioral response questions, although it is possible. Importantly, even when the animal movements are not "overlapping" with MFAS, the movement and dive data from the tags as well as the photo-identification data has been shown to provide a wealth of information which is useful to address baseline occurrence, habitat use, and behavior questions, which provide context for response questions. In FY13, the satellite tagging and photo-identification for these two projects have been funded by COMPACFLT, while M3R funding is provided by the LMR program through NUWC.

Increased transparency and collaboration. A new approach was implemented in the development of the contractor's scope of work in HRC for the final year of compliance monitoring. Due to the shift to question-based monitoring, contractors and Navy scientists were given an increased role in planning projects by requiring that the deliverables of the contracting process be in the form of progress to answers of the monitoring questions. The result has been a shift towards a less prescriptive approach that need not specify methodologies in restrictive detail. They were given the opportunity, in many cases, to propose the optimal application of effort and methods to address the monitoring question. The model is simple and not completely novel. Contractors were given a monitoring question, limits based on metrics and funding, and description of requirements. They were then asked to submit a project plan, which will be reviewed and approved by each upper level member of the team. The Navy encouraged increased transparency and collaboration between Navy scientists and contractors at the project level through the following requirements of the project protocol:

1. *Did the Technical Project Managers, Senior Technical Experts, and Navy Technical Representatives approve the protocol with a signature?*

2. *Did the protocol satisfactorily establish how monitoring question(s) will be addressed in data collection and analysis methodologies, including relevant statistics such as hypothesis and null hypothesis? Was a power analysis conducted, if appropriate?*

3. *Does protocol address the Navy Fleet monitoring requirements first and then set priorities for additional goals?*

4. *Did the protocol establish how the monitoring question(s) will be answered through collaborative data collection, analysis, and reporting?*

5. *Was the final survey plan provided to all team members no later than two weeks prior to commencement of field work?*

This new approach is in progress and is expected to be an iterative process that may eventually inform AMR and the Strategic Planning Process of the ICMP. However, it has already resulted in interesting new possibilities. For example, a comparative shore-based survey for marine mammals and sea turtles of the coastline of Niihau will be conducted this year which could result in cost savings, if proven to be equally or more effective than aerial coastline surveys. Another exciting prospect is the potential collection of much higher resolution dive data through the installation and use of an Argos uplink tower on Kauai. This process will also result in jointly written reports rather than individual appendices from each component of a project. This is intended to facilitate more integrated reports which make it easier to extract relevant information. More broadly, the process of choosing methodologies has been made more transparent by virtue of the choice of monitoring questions being informed by the SAG and rSAG processes (Section 6.1.2).

Focus on a region of HRC within which there is relatively little biological information yet a high degree of naval exercise activity. A substantial percentage of naval activity takes place in the area around Kauai and Niihau. And, although the Fleet monitoring program has concentrated survey effort in this region for several years, we still have a paucity of information about species occurrence here. The area between and to the north of Kauai and Niihau are also the locations of the hydrophone ranges at PMRF. The monitoring which has taken place there has already resulted in the first visually verified (and photographed) acoustic detection of Blainville's beaked whales on the range. FY 2013 HRC monitoring will continue to focus on this region. Aerial elliptical surveys will continue in this area in an effort to document behavioral response to MFAS through focal follows and video of cetaceans in the presence of active ships. Behavior will be examined in the context of estimated RLs which are calculated through use of data products from the PMRF hydrophone range. Aerial surveys for otherwise undetected strandings will also continue along remote shorelines of Kauai and aerial and ground-based stranding surveys will take place along the shorelines of Niihau. As described above, the visual survey effort, which includes photo-identification and satellite tagging, also occurs in this region.

Increased data accessibility and standards. At the outset of the project all participants made a full commitment to make all data available to the public, in order to ensure transparency and allow oversight by all interested stakeholders. Data collected from all past monitoring efforts in HRC, even those before the beginning of programmatic monitoring in 2009, were standardized and archived at the Navy's Environmental Information Management System (EIMS) as described in Section 3.7 and Appendix A.

Similarly, FY 2013 HRC monitoring will comply with newly developed data deliverable standards adopted on monitoring efforts across all Navy range complexes which include upload to the EIMS as well as to the publicly accessible Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP). These standards will ensure ready consistency of survey data facilitating analyses across field efforts whether occurring on different platforms, range complexes, and years.

Discussion of the Final Year Compliance Monitoring. The fifth year of the monitoring program in HRC through 31 July 2013, follows the current year HRC monitoring plan. The metrics of this monitoring plan are both an extension of the plans of previous years but have also been informed by various processes related to AMR. For example, compliance metrics of effort are still continued for visual survey, MMOs, and tagging. However, the requirements for acoustic methodologies place greater emphasis on the analysis of collected data and are also defined less by effort than in previous plans, allowing greater flexibility with the goal of better facilitating the answering of study questions. The implementation of the HRC monitoring plan in the fifth year has also been informed by processes in other range complexes. The 2012–15 LOA for the MIRC included a range complex monitoring plan that removed metrics of effort, and replaced these with the metric of evaluating progress on answering study questions. An immediate consequence is a greatly enhanced flexibility of choice of monitoring methods to be directed toward the goals of answering monitoring-related study questions. The MIRC monitoring plan is a possible model for implementing similar changes to the monitoring plans for all range complexes; a process which may be realized through the ICMP's strategic planning process.

At the annual 2012 AMR meeting between NMFS and the Navy, NMFS gave direction allowing even greater flexibility by the Navy, stating that in cases where study questions could be more optimally approached, NMFS approved of the Navy making adjustments in monitoring plan requirements, if reasonable documentation of the reasons were provided. As applied to HRC monitoring, even before the evaluation of monitoring accomplishments solely based on study questions is realized and implemented in the future, this guidance already provides greater flexibility in the current fifth year of monitoring for a transparent decision-making process to choose the methodologies optimally suited for a successful monitoring program. This evolution will continue through 2013 in order to focus resources on methods and projects proposed by the scientific community through the Strategic Planning Process, which offers the best opportunity for advancing our knowledge and addressing ICMP top-level goals U.S. Navy-wide.

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9 APPENDICES

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