Hawaii-Southern California Training and Testing (HSTT)

2014 Annual Monitoring Report

Prepared For and Submitted To

National Marine Fisheries Service

Office of Protected Resources

Prepared By

Department of the Navy

In accordance with 50 CFR Part 216.245(e)

APRIL 2015

Citation for this report is as follows:
DoN (Department of the Navy). 2015. *Hawaii-Southern California Training and Testing (HSTT) - 2014 Annual Monitoring Report.* Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Prepared for and submitted to National Marine Fisheries Service, Silver Spring, Maryland.

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Photo 2. Blainville’s beaked whale (*Mesoplodon densirostris*), photographed by Mark Deakos, taken under NMFS Permit No. 14451.
Photo 3. Green turtle (*Chelonia mydas*) off Kauai. Photo courtesy of U.S. Navy.
Photo 4. Fin whale offshore in Southern California (*Balaenoptera physalus*), photographed by Craig Hayslip, Oregon State University Marine Mammal Institute, taken under NMFS Permit No. 14856.
Photo 5. Humpback whales (*Megaptera novaeangliae*), photographed by Joe Mobley, taken under NMFS Permit No. 642-1536-03.
Photo 6. Blue whale offshore in Southern California (*Balaenoptera musculus*), photographed by Craig Hayslip, Oregon State University Marine Mammal Institute, taken under NMFS Permit No. 14856.
Photo 7. University of Washington, Applied Physics Laboratory (APL) staff deploying acoustic equipment at the Silver Strand Training Complex. Photo courtesy of APL.

REPORT DOCUMENTATION PAGE	*Form Approved* **OMB No. 0704-0188**

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
04-2015	Monitoring report	01 January 2014 - 31 December 2014

4. TITLE AND SUBTITLE Hawaii-Southern California Training and Testing (HSTT) - 2014 Annual Monitoring Report	**5a. CONTRACT NUMBER** N62470-10-D-3011
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Department of the Navyl	**5d. PROJECT NUMBER** KB28
	5e. TASK NUMBER 4
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commander, U.S. Pacific Fleet, 250 Makalapa Dr., Pearl Harbor, HI	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Sponsoring Agency: Chief of Naval Operations (N45), 2511 Jefferson Davis Highway, Arlington, VA	**10. SPONSOR/MONITOR'S ACRONYM(S)**
	11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report contains a summary of United States (U.S.) Pacific Fleet-funded monitoring projects and results from calendar year 2014 within the U.S. Navy's Hawaii-Southern California Training and Testing (HSTT) Study Area. The Study Area includes three existing U.S. Navy range complexes: Southern California Range Complex (SOCAL), Hawaii Range Complex (HRC), and Silver Strand Training Complex (SSTC). Concurrent with Phase II of the U.S. Navy's Marine Species Monitoring Program, the U.S. Navy and National Marine Fisheries Service (NMFS) agreed to shift to compliance based on demonstrated progress addressing scientific questions and objectives, and results in this report are therefore presented in the context of the questions and study objectives they address. Fiscal Year (FY) 14 was a transitional year, with ongoing data collection spanning the shift from Phase I (i.e., effort-based metrics) to Phase II (i.e., question-based metrics) as well as ''carry-over'' projects or analysis from Phase I. Some projects leveraged funding from the U.S. Navy's Living Marine Resources (LMR) and Office of Naval Research (ONR) research programs.
Overall, 2014 monitoring efforts focused on documenting the occurrence of marine species in U.S. Navy training ranges and estimating the exposure of these animals to sonar and explosives. Some highlights of this progress include:
• A novel, integrated approach used Pacific Missile Range Facility (PMRF) instrumented range data to estimate received sound levels (RLs) for three species of tagged marine mammals. A tagged bottlenose dolphin (Tursiops truncatus) showed no large-scale movements out of the area during sonar exposures despite relatively high estimated RLs, and a short-finned pilot whale (Globicephala macrorhynchus) actually moved towards areas of higher estimated exposures.
• An automated method was developed to track humpback whales (Megaptera novaeangliae) at PMRF using song units attributable to individual animals. This method processes data five times faster than real-time with a predicted high level of spatial accuracy.

• During visual line-transect surveys for coastal waters of the SSTC and north San Diego Bay, a rare sighting of false killer whales (Pseudorca crassidens) was recorded. With a year and half of monthly surveys, small scale density estimates for California sea lions (Zalophus californianus) and common dolphins (Delphinus spp.) will be generated in support of future modeling efforts.
• Cuvier's beaked whales (Ziphius cavirostris) detected at the Southern California Anti-submarine Warfare Range (SOAR) were found to be persistently present in an area of repeated sonar use, suggesting that these whales may be part of a smaller regional subpopulation, rather than transient members of a large and dispersed west coast population. In addition, a subpopulation of non-transitory fin whales (Balaenoptera physalus) is also hypothesized based on results from monitoring between 2010 and 2014.
• Transition of the research from the Marine Mammal Monitoring on Navy Ranges (M3R) began this year with the anticipation of new data products aligned with region specific study questions applicable to PMRF and SOAR. As a first data product coming out of M3R transition efforts, M3R is close to being able to provide monthly beaked whale detection and density estimates within PMRF and SOAR.
• Long-term satellite tracking of blue whales (Balaenoptera musculus) in Southern California detailed new information on individual animal movement patterns and residence times. The influence of an unusually warm-water period in the late summer of 2014 was documented with many of the tagged blue whales leaving Southern California for the Eastern Tropical Pacific earlier than any time previously (1993 to 2008). Relatively few of the tagged blue whales stayed long within the SOCAL range complex. Additionally, there was no to limited transitory activity within or adjacent to recently published Biologically Important Areas for blue whales (those within the SOCAL range complex).
• Newly developed Advanced Dive Behavior tags attached to blue and fin whales in Southern California provided new science on short-term (5-30 days) animal movements and foraging behavior both within the SOCAL range complex and outside.
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• Minke whale (Balaenoptera acutorostrata) acoustic detections lead to a minimum density estimate at PMRF as well as data suggesting minke whales are responding acoustically to mid-frequency active sonar.

15. SUBJECT TERMS
Monitoring, marine mammal, adaptive management review, Southern California Range Complex, Hawaii Range Complex

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
			UU	87	Department of the Navy
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPONE NUMBER (*Include area code*)**
Unclassified	Unclassified	Unclassified			808-471-6391

Executive Summary

The United States (U.S.) Navy uses the Hawaii-Southern California Training and Testing (HSTT) Study Area for at-sea training, as described in the HSTT Environmental Impact Statement (EIS) (Department of Navy [DoN] 2013a). In support of the continuation of training and testing described in the HSTT EIS and the 5-year Final Rule (National Marine Fisheries Service [NMFS] 2013a), NMFS issued Letters of Authorization (NMFS 2013b,c) and a Biological Opinion (NMFS 2014) to the U.S. Pacific Fleet and the System Commands (SYSCOMS) in April 2014 (NMFS 2014). Phase II of the U.S. Navy's Marine Species Monitoring Program began in 2014 in accordance with these documents. Marine species monitoring was conducted in accordance with project objectives listed on the U.S. Navy's Marine Species Monitoring website: http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/

This report contains a summary of U.S. Pacific Fleet-funded monitoring projects and results from calendar year 2014 within the U.S. Navy's HSTT Study Area. The Navy's SYSCOMS participated in the planning and will contribute to funding future monitoring evolutions. The Study Area includes three existing U.S. Navy range complexes: Southern California Range Complex (SOCAL), Hawaii Range Complex (HRC), and Silver Strand Training Complex (SSTC). Concurrent with Phase II of the U.S. Navy's Marine Species Monitoring Program, the U.S. Navy and NMFS agreed to shift to compliance based on demonstrated progress addressing scientific questions and objectives, and results in this report are therefore presented in the context of the questions and study objectives they address. Fiscal Year (FY) 14 was a transitional year, with ongoing data collection spanning the shift from Phase I (i.e., effort-based metrics) to Phase II (i.e., question-based metrics) as well as ''carry-over'' projects or analysis from Phase I. Some projects leveraged funding from the U.S. Navy's Living Marine Resources (LMR) and Office of Naval Research (ONR) research programs.

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- An automated method was developed to track humpback whales (*Megaptera novaeangliae*) at PMRF using song units attributable to individual animals. This method processes data five times faster than real-time with a predicted high level of spatial accuracy.
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Acronyms and Abbreviations

ADB	advanced dive behavior
AMR	Adaptive Management Review
AUTEC	Atlantic Undersea Test and Evaluation Center
BSS	Beaufort Sea State
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CFR	Code of Federal Regulations
CG	Guided Missile Cruiser
CI	Confidence Interval
CSEL	cumulative sound exposure level
CS-SVM	Class-Specific Support Vector Machine
dB	decibel(s)
dB re: 1µPa	decibel(s) referenced to 1 micro Pascal
DDG	Guided Missile Destroyer
EAR	ecological acoustic recorder
ESA	Endangered Species Act of 1973
F/V	Fishing Vessel
FY	Fiscal Year
HARP	high-frequency acoustic recording package
hr	hour(s)
HRC	Hawaii Range Complex
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
km/hr	kilometer(s) per hour
LFAS	low-frequency active sonar
LOE	lookout effectiveness
m	meter(s)
m/s	meter(s) per second
M3R	Marine Mammal Monitoring on Navy Ranges
MFAS	mid-frequency active sonar
min	minute(s)
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act of 1972
MTE	Major Training Event
NMFS	National Marine Fisheries Service
NSDB	north San Diego Bay
NWTRC	Northwest Training Range Complex
PAAM	Passive Autonomous Acoustic Monitoring
PAM	Passive Acoustic Monitoring
PMRF	Pacific Missile Range Facility
pp	peak-to-peak
R/V	Research Vessel
RIMPAC	Rim of the Pacific
RL	received level
RMS	root mean square
ROCCA	Real-time Odontocete Call Classification Algorithm
SCC	Submarine Commanders Course
SCI	San Clemente Island
SEL	sound exposure level
SOAR	Southern California Anti-submarine Warfare Range
SOCAL	Southern California Range Complex
SPAWAR	Space and Naval Warfare Systems Command
SPOT	Smart Position and Temperature
SPUE	sightings per unit effort
SSTC	Silver Strand Training Complex
TDOA	time difference of arrival
UNDET	underwater detonation
U.S.	United States
v.	versus

1. Introduction

This report contains a summary of United States (U.S.) Pacific Fleet-funded monitoring conducted in calendar year 2014, within the U.S. Navy's Hawaii-Southern California Training and Testing (HSTT) Study Area. The U.S. Navy conducts marine mammal and sea turtle monitoring for compliance with the Letter of Authorization (NMFS 2013b,c) and Biological Opinion (NMFS 2014) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing in the HSTT Study Area. This report also reflects an evolution in the approach to monitoring reports for this area. Concurrent with Phase II of the U.S. Navy's Marine Species Monitoring Program, the U.S. Navy and the National Marine Fisheries Service (NMFS) have agreed to establish compliance based on demonstrated progress towards addressing scientific questions and objectives, rather than on specific monitoring requirements for each range complex from effort-based metrics. Therefore, results in this report are organized by monitoring questions and objectives, and specifically how these were addressed by a particular project.

1.1 Background

The HSTT Study Area is comprised of established operating and warning areas in the north-central Pacific Ocean, from Southern California west to Hawaii and the International Date Line (**Figure 1**). The Study Area includes three existing U.S. Navy range complexes: the Southern California Range Complex (SOCAL), Hawaii Range Complex (HRC), and Silver Strand Training Complex (SSTC). In addition to naval range complexes, the HSTT Study Area includes other areas where training and testing activities occur, including pier-side locations in San Diego Bay and Pearl Harbor, the transit corridor between SOCAL and HRC, and other locations throughout San Diego Bay. The majority of active sonar occurs in SOCAL and HRC; however, hull-mounted mid-frequency active sonar (MFAS) is not typically used in the San Diego Arc area during Major Training Events (MTEs). SSTC is used primarily for explosive and pile-driving activities.

In order to issue an Incidental Take Statement for an activity that has the potential to affect protected marine species, NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking" (50 Code of Federal Regulations [CFR] Part 216.101(a)(5)(a)). A request for a Letter of Authorization must include a plan to meet the necessary monitoring and reporting requirements, while increasing the understanding, and minimizing the disturbance, of marine mammal and sea turtle populations expected to be present. While the ESA does not have a specific monitoring requirement, the Biological Opinion issued in April 2014 by NMFS for the HSTT Study Area includes terms and conditions for continued monitoring in this region (NMFS 2014).

Current marine species monitoring projects being conducted in the HSTT Study Area in support of MMPA and ESA authorizations are listed on the U.S. Navy Marine Species Monitoring website (http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/). This report contains a review of progress made on these projects in 2014. Final reports and data from these projects will be made available on the individual project profile pages and the Reading Room at the U.S. Navy Marine Species Monitoring website as they become available.

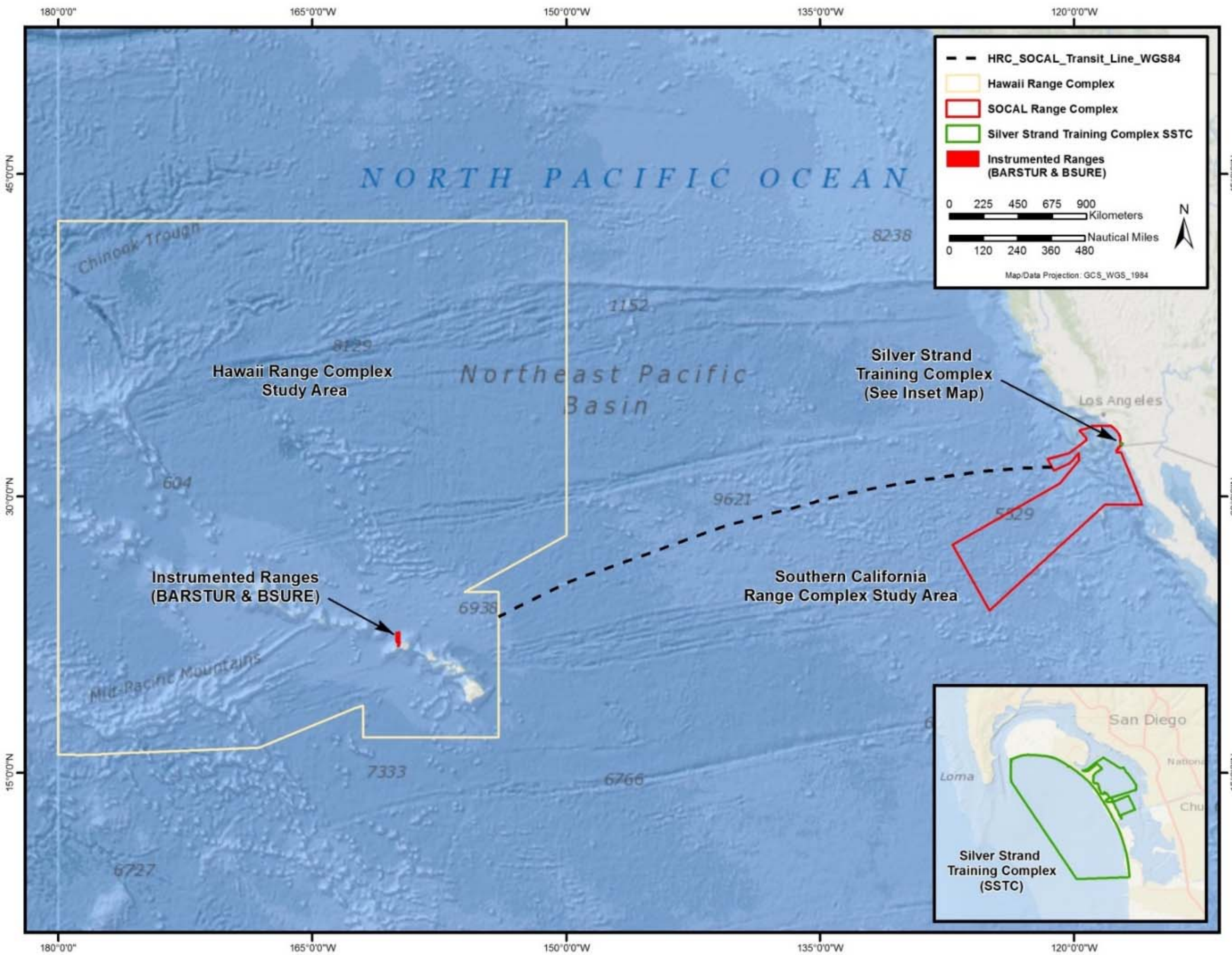

Figure 1. HSTT Study Area.

1.2 Integrated Comprehensive Monitoring Program and the Strategic Planning Process

The Integrated Comprehensive Monitoring Program (ICMP) serves as a framework and planning tool to focus U.S. Navy monitoring priorities pursuant to ESA and MMPA requirements (Department of the Navy [DoN] 2010). The purpose of the ICMP is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the ICMP does not identify specific monitoring or field projects, it is designed to provide a flexible, scalable, and adaptable framework for such projects using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives.

The ICMP is evaluated annually 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 monitoring plan modifications are warranted, in order to address program goals more effectively. Modifications to the ICMP that result from AMR discussions are incorporated by an addendum or revision to the ICMP. As a planning tool, the ICMP is a "living document." It will be routinely updated as the program progresses with the most recent revision in 2013/2014 with the addition of the Strategic Planning Process (CNO 2013).

Under the ICMP, U.S. Navy-funded monitoring relating to the effects of U.S. Navy training and testing activities on protected marine species should be designed to accomplish one or more top-level goals as described in the current version of the ICMP (DoN 2010). Chief of Naval Operations Environmental Readiness Division is responsible for maintaining and updating the ICMP, as necessary, reflecting the results of regulatory agency rulemaking, AMRs, best available science, improved assessment methods, and more effective protective measures. This is performed as part of the AMR process, in consultation with U.S. Navy technical experts; U.S. Pacific Fleet, and Echelon II Commands as appropriate.

1.3 Report Objectives

This report presents the 2014 results and progress made on monitoring questions/objectives in the HSTT Study Area as well as providing a cumulative view of how the results build upon the prior five years of monitoring in SOCAL and HRC.

This report has two main objectives:

1. Summarize findings from U.S. Pacific Fleet-funded marine mammal and sea turtle monitoring conducted in the HSTT Study Area in 2014, as well as monitoring data analyses performed during this time period. Detailed technical reports for these efforts are referenced throughout this report and provided as stand-alone supporting documents.

2. Continue the AMR by assessing how data collected and/or analyzed over the past year have improved the ability to address monitoring questions and achieve project objectives, and improved the understanding of the occurrence and distribution of marine mammals and sea turtles that may be exposed to sonar and explosives in the HSTT Study Area.

Considerable progress has been made during the reporting period on addressing the monitoring questions. Highlights of this progress include:

A novel, integrated approach used Pacific Missile Range Facility (PMRF) instrumented range data to estimate received sound levels (RLs) for three species of tagged marine mammals. A tagged bottlenose dolphin (*Tursiops truncatus*) showed no large-scale movements out of the area during sonar exposures despite relatively high estimated RLs, and a short-finned pilot whale (*Globicephala macrorhynchus*) actually moved towards areas of higher estimated exposures.

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Minke whale (*Balaenoptera acustorostrata*) acoustic detections lead to a minimum density estimate at PMRF as well as data suggesting minke whales are responding acoustically to mid-frequency active sonar.

Overall, monitoring efforts during 2014 focused on documenting the occurrence of marine species in U.S. Navy training ranges, and estimating the exposure of these animals to sonar and explosives, when possible. This focus is consistent with the recommendations of NMFS during the MMPA Rulemaking Process and reiterated by the Scientific Advisory Group convened by the U.S. Navy in March 2011 (DoN 2011) to address monitoring priorities in various U.S. Navy training ranges.

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2. Marine Species Monitoring in the Hawaii Range Complex

2.1 2014 HRC Monitoring Goals and Implementation

Table 1 summarizes current HRC marine species monitoring projects conducted in 2014, in support of HSTT MMPA requirements (50 CFR Part 128). Intermediate scientific objectives are identified for each project here: (http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/), as well as a brief summary of how each objective was met in 2014.

Table 1. 2014 HRC monitoring goals.

Project	Intermediate Scientific Objectives	2014 Completed Requirements – Progress Made on the Following Monitoring Questions
PROJECT #1: Analysis of existing passive acoustic data. STATUS: COMPLETED	• Determine what species and populations of marine mammals and sea turtles are present in U.S. Navy range complexes. • Continue development of PAM techniques and tools for detecting, classifying, and localizing marine mammals. • Determine what populations of marine mammals are exposed to U.S. Navy training and testing activities. • Establish the baseline vocalization behavior of marine mammals where U.S. Navy training and testing activities occur. • Develop analytic methods to evaluate behavioral responses based on PAM techniques. • Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities.	• What species of beaked whales *(Ziphius/Mesoplodon)* are heard in and around the Niihau area of the HRC? (See Table 7, Figure 8, in Lammers et al. 2015 **[1a].**) • What is the seasonal occurrence of baleen whales (minke, fin, possibly sei) heard in the HRC around the Niihau area? (See Section 3E in Lammers et al. 2015 **[1a].**) • What is the occurrence of sperm whales heard in the HRC around the Niihau area? (See Table 7, Figure 8, Figure 32, Figure 33, in Lammers et al. 2015 **[1a].**) • What species of delphinids occur in the HRC around the Niihau area? (See Table 8, Figure 9, Table 9, Figures 11-13, Figure 15 in Lammers et al. 2015 **[1a].**) • Do beaked whale *(Ziphius/ Mesoplodon)*, baleen whale (minke, fin, possibly sei), sperm whale, and delphinid detection rates vary before, during, and after MFAS detections? (See Figure 21, Figure 22, Figure 23-26, Table 10, Table 11, in Lammers et al. 2015 **[1a].**)
PROJECT #2: Marine species monitoring prior to U.S. Navy training. STATUS: ONGOING	• Determine which species and populations of marine mammals and sea turtles are present in U.S. Navy range complexes. • Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities. • Establish the baseline habitat uses and movement patterns	• What are the spatial movement patterns and habitat use (e.g., island-associated or open-ocean, restricted ranges v. large ranges) of species that are exposed to MFAS and how do these patterns influence exposure and potentially response? (See Figure 4, Figure 8, Table 1, Tables 6-11, Results, Discussion and Conclusion in Baird et al. 2014a **[2a]**; Figure 4, Table 4 in Deakos and Richlen 2015 **[2b]**; Figures 5-13, Table 1, Tables 6-10, Section 5, Section 6 **[2c]**.)

Project	Intermediate Scientific Objectives	2014 Completed Requirements – Progress Made on the Following Monitoring Questions
	of marine mammals where U.S. Navy training and testing activities occur.	
PROJECT #3: Marine species monitoring at PMRF during U.S. Navy training events. STATUS: ONGOING	• Continue development of PAM techniques and tools for detecting, classifying, and localizing marine mammals. • Determine what populations of marine mammals are exposed to U.S. Navy training and testing activities. • Develop analytic methods to evaluate behavioral responses based on PAM techniques. • Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities.	• What are the estimated RLs of MFAS to which marine mammals are exposed during ASW training, and what, if any, behavioral effects result at various levels? (See Results: "Estimated Received Levels—Focal Follow Pods," Table 4 in Mobley et al. 2015 **[3a]**; Results and Discussion, Figures 2 and 3, Tables 1 and 2 in Martin et al. 2014 **[3b]**; Results and Discussion, Tables 1-3 in Henderson et al. 2015 **[3c]**.)
PROJECT #4: Marine species monitoring following U.S. Navy training events. STATUS: ONGOING	• Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities.	• Do marine mammals strand along shorelines of the Main Hawaiian Islands within one week following a U.S. Navy training event? (See Section 4, Figure 4, Tables 1 and 2, Appendix A in Ampela et al. 2015 **[4a]**; Section 4, Table 1, Figures 2-7 in Mobley and Deakos 2015 [**4b]**.)
PROJECT #5: Marine Species Observers embarked on U.S. Navy assets during ASW training and UNDET training and testing activities. STATUS: ONGOING	• Determine the effectiveness of U.S. Navy watchstanders/lookouts. • Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities.	• What is the effectiveness of U.S. Navy lookouts when implementing protective measures? (See Tables 3 and 4 in Vars et al. 2014 **[5a]**; Tables 3 and 4 in Shoemaker et al. 2014 **[5b]**; Tables 3 and 4 in Dickenson et al. 2014 **[5c]**.) • Which marine mammals are observed in the vicinity of ASW and UNDET training that could be exposed to U.S. Navy sound sources? (See Section 3, Table 1 in Soloway and Dahl 2015 [**5d]**.)
PROJECT #6: Meta-analysis of HRC monitoring and other existing data sets - possible inclusion of other existing data in on-going analysis. STATUS: ONGOING	• Assess existing data sets which could be utilized to address the above objectives.	• How does our ability to address questions of exposure (integrating propagation models and animal occurrence) vary with species/species groups? (See Results and Discussion, Figures 1-7, Tables 1 and 2 in Baird et al. 2014c **[6a]**.) • How well is baseline occurrence (distribution, density and habitat use) known/defined (short- to medium-term) across species groups? (See Table 1, Figures 4-8 in Martin and Matsuyama 2015 **[6b]**; Sections 3A and 3B, Figure 1, Figure 8 in Helble et al. 2015a **[6c]**.)

Key: ASW = anti-submarine warfare; HRC = Hawaii Range Complex; MFAS = mid-frequency active sonar; PAM = passive acoustic monitoring; PMRF = Pacific Missile Range Facility; RL = received level; UNDET = underwater detonation; U.S. = United States; v. = versus.

2.1.1 Timeline of HRC Monitoring Efforts

The Hawaii Range Complex is depicted in **Figure 2**. All U.S. Pacific Fleet-funded monitoring and research tasks implemented in the HRC in 2014 are illustrated in **Figure 3**. It should be noted that for several of these projects, field work and data collection occurred prior to 2014, but data analysis occurred within the 2014 reporting period. Details of individual tasks, organized by project, are in the following sections.

Project 1: Analysis of Existing Passive Acoustic Data

[1a] Passive Acoustic Monitoring of Cetaceans in the Hawaii Range Complex Using Ecological Acoustic Recorders (EARs) [Lammers et al. 2015]

From 2011 through 2013, four ecological acoustic recorders (EARs) were deployed off the islands of Niihau and Kaula (**Figure 4**). EARs are passive acoustic recorders intended to capture sounds produced by vocalizing whales and dolphins. The recorded acoustic data were analyzed using a combination of manual and automated techniques to detect and to classify cetacean sounds (to determine species identification) and to determine species occurrence in the region. Analysis provided an assessment of the accuracy of the automated methods, an interpretation of click classifications, and investigated whether MFAS had any impact on the vocal behavior of the recorded marine mammals.

[1b] Autonomous Underwater Vehicle Acoustic Surveys [Klinck 2015]

A Passive Autonomous Acoustic Monitoring (PAAM) package with a bandwidth of 15 Hertz (Hz) to 97 kilohertz (kHz) was mounted onto a Seaglider™ (Kongsberg Maritime) and deployed off Honolulu on for a 47-day acoustic survey south of the Main Hawaiian Islands, covering approximately 600 kilometers (km) of trackline (**Figure 5**) (Note: Although this project falls under **Project 1**, the data had not yet been analyzed as of this writing.)

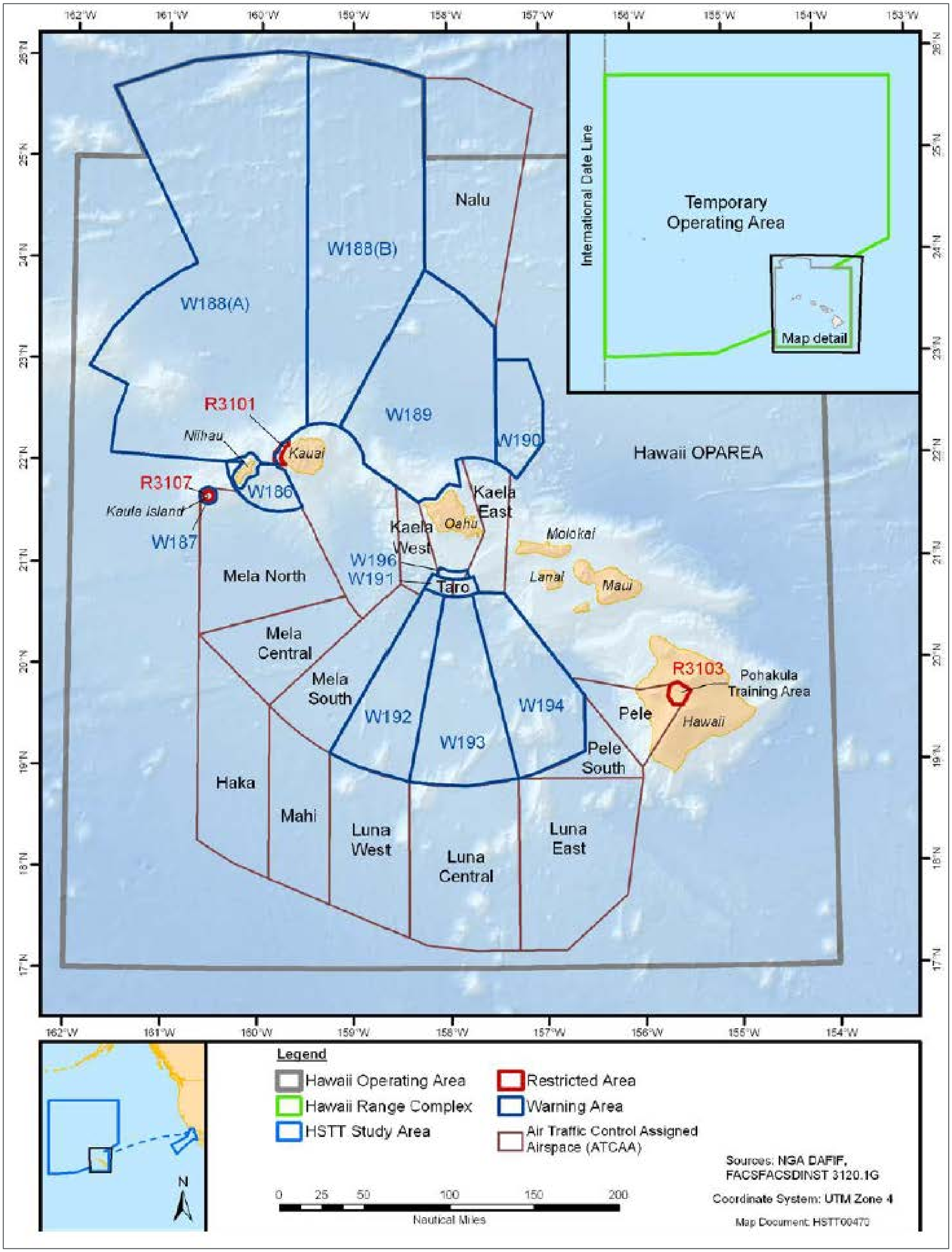

Figure 2. The Hawaii Range Complex

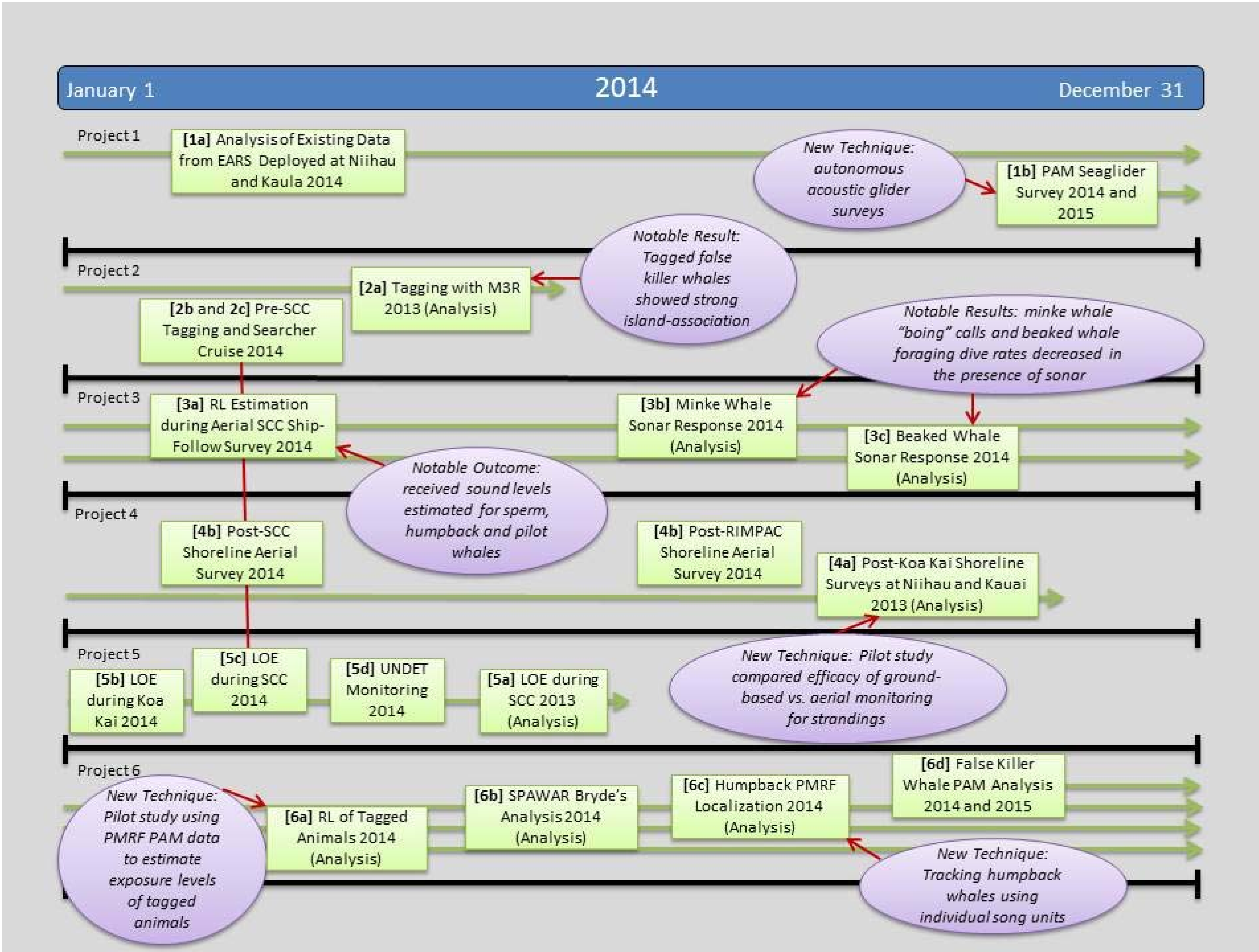

Figure 3. Timeline of 2014 HRC monitoring projects.

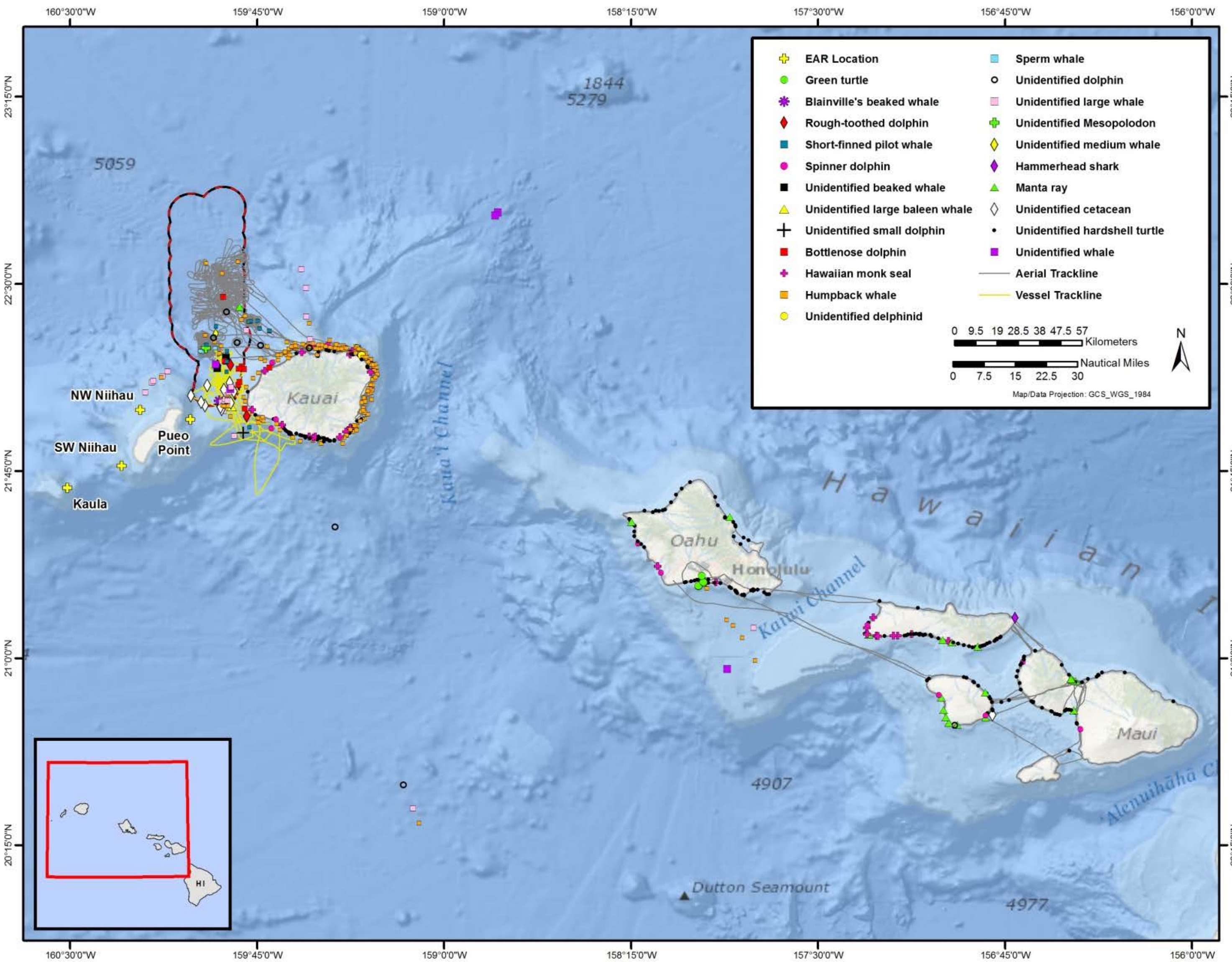

Figure 4. Sightings and effort from visual surveys conducted in HRC in 2014 (see reports [2b], [3a], [4b], [5c], and [5d]). Also shown are locations of EARs deployed prior to 2014. Aerial survey tracklines are shown in gray, while vessel survey tracklines are shown in yellow. No effort from LOE surveys is displayed.

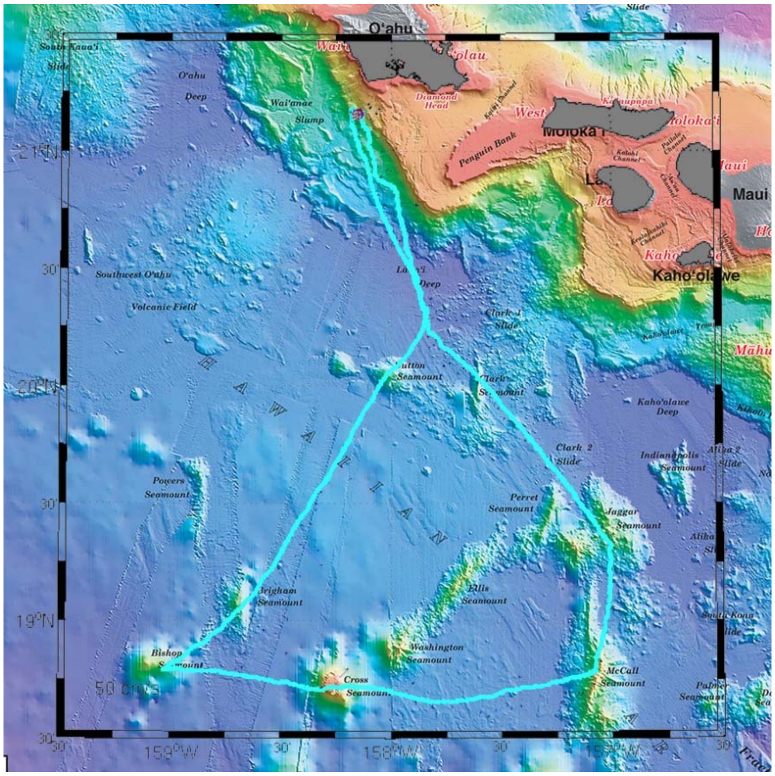

Figure 5. Trackline of an autonomous underwater vehicle used for acoustic surveys south of the Main Hawaiian Islands (Klinck 2015 [1b]).

Project 2: Marine Species Monitoring Prior to U.S. Navy Training Events

[2a] Odontocete Studies on the Pacific Missile Range Facility in July/August 2013: Satellite-tagging, Photo-identification, and Passive Acoustic Monitoring [Baird et al. 2014a]

Prior to a Submarine Commanders Course (SCC) training event in August 2013, non-random, non-systematic small-vessel surveys were conducted on and around PMRF. Surveys were conducted as a joint project with the M3R real-time PAM system located at PMRF (Moretti and Baird 2015). M3R detections were used to help locate animals for satellite-tag deployment, and visual observations provided validation of acoustic detections. High-resolution photographs of all marine mammal sightings were collected for photo-identification and biopsy sampling was conducted for genetic studies. (Note: although tags are deployed prior to the training event, the tags have the potential to remain attached to the animal for several weeks, and therefore recovered data may overlap in space and time with training events.)

[2b] Vessel-based Marine Mammal Survey on the Navy Range off Kauai in Support of Passive Acoustic Monitoring and Satellite Tagging Efforts, 01-09 February 2014 [Deakos and Richlen 2015]

Prior to an SCC training event in February 2014, a non-random, non-systematic large-vessel visual survey was conducted, primarily focused on and around PMRF, aboard the Research Vessel (*R/V*) *Searcher*. Surveys were conducted as a joint project with the M3R real-time PAM system located at PMRF and the small vessel survey **[2c]**. M3R detections and large vessel detections were used to help locate animals for satellite-tag deployment from the small vessel, and visual observations provided validation of acoustic detections. High-resolution photographs of all marine mammal sightings were collected for photo-identification.

[2c] Odontocete Studies on the Pacific Missile Range Facility in February 2014: Satellite-tagging, Photo-identification, and Passive Acoustic Monitoring [Baird et al. 2014b]

Prior to an SCC training event in February 2014, small-vessel surveys were conducted on and around PMRF. Surveys were conducted as a joint project with the M3R real-time PAM system located at PMRF (Moretti and Baird 2015) and the large-vessel survey **[2b]**. M3R detections were used to help locate animals for satellite-tag deployment, and visual observations provided validation of acoustic detections. High-resolution photographs of all marine mammal sightings were collected for photo-identification and biopsy sampling was conducted for genetic studies. (Note: although tags are deployed prior to the training event, the tags have the potential to remain attached to the animal for several weeks; therefore, recovered data may overlap in space and time with the naval training event.) M3R recordings also were made for several species in conjunction with visual observations in order to improve species classification for future acoustic monitoring efforts. In addition, Blainville's beaked whale detection archives in M3R were reviewed and analyzed in order to derive the spatial and temporal distribution of this species on PMRF, as well as to estimate abundance.

Project 3: Marine Species Monitoring at PMRF during U.S. Navy Training Events

[3a] Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event, SCC February 18-20, 2014 [Mobley et al. 2015]

Marine mammal and sea turtle monitoring was conducted from a fixed-wing aircraft during an SCC training event in February 2014. The aircraft flew elliptical-shaped orbits in advance of a U.S. Navy warship. Marine mammal observers (MMOs) aboard the aircraft monitored an area within approximately 5 km of the warship. Upon detection of an animal or group of animals in this range, observers recorded the animals' behavior, as well as determined species, group size, and direction of travel. When pods were observed close to the warship (i.e., within 5 km) and were judged to be suitable, focal follows were performed in order to record the animals' behavior with a video camera. Post-processing resulted in estimated RLs of MFAS for several animal groups that were exposed to MFAS during the training event.

[3b] Minke Whales Respond to U.S. Navy Training in Hawaiian Waters [Martin et al. 2014]

Minke whales were acoustically detected and localized, via their boing vocalizations, using recorded data from the PMRF instrumented range. All available recorded data from 24 seafloor-mounted hydrophones were processed to localize boing-calling minke whales before, during, and after U.S. Navy training events that occurred in the month of February over 3 years (2011 through 2013).

[3c] Impacts of U.S. Navy Training Events on Beaked Whale Foraging Dives in Hawaiian Waters: Update [Henderson et al. 2015]

Using archived acoustic data obtained from 31 seafloor-mounted hydrophones from the PMRF range before, during and after training events between 2011 and 2013, changes in Blainville's beaked whale dive counts were correlated with periods of MFAS use to assess the impact of

MFAS on the animals dive behavior. This builds upon the analysis conducted for one 2012 event reported in Manzano-Roth et al 2012.

Project 4: Marine Species Monitoring Following U.S. Navy Training Events

[4a] Aerial and Ground-based Shoreline Surveys for Marine Mammals and Sea Turtles in the Hawaii Range Complex, Conducted After a Navy Training Event [SCC 12-13 August 2013) (Ampela and Mobley 2013]

Aerial (helicopter) and ground-based (vehicle and horseback) shoreline surveys were conducted concurrently in order to compare the efficacy of each method in detecting stranded marine mammals. Observers scanned the shorelines of Kauai and Niihau, adjacent to PMRF, for stranded and near-stranded marine mammals and sea turtles within one week after an SCC training event in August 2013. Surveys circumnavigated the islands of Kauai and Niihau by helicopter, and by vehicle/foot/horseback on the island of Niihau. At Niihau, where both aerial and ground-based surveys occurred, the relative detectability of animals from each of these platforms was compared using the recorded number and location of Hawaiian monk seals *(Monachus schauinslandi)*, which served as a “proxy” for stranded marine mammals. In addition, survey teams assessed the feasibility of circumnavigating Niihau while maintaining continual visual coverage of shoreline areas, and identified potential coastal routes appropriate for patrolling the shoreline on a regular basis.

[4b] Aerial Shoreline Surveys for Marine Mammals and Sea Turtles in the Hawaii Range Complex, Conducted After Navy Training Events. Koa Kai Surveys: 31 January and 5 February 2014. RIMPAC Surveys: 1 and 4–6 August 2014 [Mobley and Deakos 2015]

Aerial shoreline surveys were conducted by helicopter to monitor for marine mammal and/or sea turtle strandings, or near strandings, following two U.S. Navy training events (Koa Kai and Rim of the Pacific [RIMPAC]) involving the use of MFAS in January/February and August 2014. Post-event monitoring surveys were conducted near areas where the respective training occurred. In addition to surveying for stranded or near-stranded marine mammals, sightings of regularly occurring target species were also recorded.

Project 5: Marine Species Observers Embarked on U.S. Navy Assets during Anti-submarine Warfare Training and Underwater Detonation Training and Testing

[5a] Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Submarine Commanders Course, August 2013, Hawaii Range Complex [Vars et al. 2014]

[5b] Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study Koa Kai, January 2014, Hawaii Range Complex [Shoemaker et al. 2014]

[5c] Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Submarine Commanders Course, February 2014, Hawaii Range Complex [Dickenson et al. 2014]

MMOs embarked on U.S. Navy vessels during three separate U.S. Navy training events: a Koa Kai (January 2014) and two SCC (one in August 2013 the other in February 2014). For all three events, MMOs followed a prescribed protocol to collect data that will be pooled with other embarks and analyzed to assess the effectiveness of U.S. Navy lookouts. In addition, MMOs recorded marine mammal and sea turtle sightings in order help determine the species and populations that are exposed to U.S. Navy training events in the HRC.

[5d] Cruise Report, Marine Mammal and Sea Turtle Observer UNDET Monitoring in the Hawaii Range Complex: 3 April 2014 [Fagan and Shannon 2015]

In conjunction with underwater detonation (UNDET) training at the Puuloa Underwater Range, MMOs conducted marine mammal and sea turtle monitoring from a small vessel that accompanied the demolition team. Prior to detonations, MMOs observed a thorough search made by the U.S. Navy lookouts to identify the presence of marine mammals or sea turtles within the exclusion zone surrounding the UNDET area prior to and following the exercise. In addition to visual marine species monitoring, underwater recordings were made with a dipping hydrophone during training in order to collect data on ambient sound levels before and after UNDETs.

Project 6: Meta-analysis of HRC Monitoring and Other Existing Data Sets - Possible Inclusion of Other Existing Data in On-going Analysis

[6a] Assessment of Modeled Received Sound Pressure Levels and Movements of Satellite-tagged Odontocetes Exposed to Mid-frequency Active Sonar at the Pacific Missile Range Facility: February 2011 through February 2013 [Baird et al. 2014c]

A pilot study was conducted to assess the utility of using PMRF data products, such as MFAS transmission times and ship position, to estimate RLs for satellite-tagged marine mammals in order to determine if there were any large scale movements (or lack thereof) in response to MFAS. Several species of small odontocetes were instrumented with satellite tags just before U.S. Navy training events at PMRF, so that animal movements and diving behavior could be measured both before and during sonar use.

[6b] Bryde's Whales Acoustically Detected, Localized and Tracked in PMRF Recorded Data [Martin and Matsuyama 2015]

The monitoring questions addressed in this analysis were further refined to: (*1) What were the received levels of tagged animals in the vicinity of February 2011 SCC, July/August 2011 SCC, and February 2012 SCC or other U.S. Navy trainings? (2) Were there any large-scale movements away from the naval training? (3) What are the baseline short-term and long-term movement rates for tagged animals?*

Acoustic recordings archived from 2013 and 2014 at PMRF were examined for evidence of baleen whale vocalizations. Low-frequency pulsed signals between 15 and 50 Hz identified as Bryde’s whales were detected, localized, and tracked providing information about the whales’ acoustic behavior, swim speed, direction of travel, and call rates.

[6c] Automated Acoustic Localization and Call Association for Vocalizing Humpback Whales on the Navy’s Pacific Missile Range Facility [Helble et al. 2015a]

Archived acoustic data collected using the PMRF instrumented hydrophone range was auto-processed to detect, localize, and track vocalizing humpback whales (see also Helble et al. 2015b). Since multiple individual humpback whales vocalize simultaneously on breeding grounds in Hawaiian waters, novel techniques were developed to associate calls with individual animals in order to localize and track the animals. A time difference of arrival method was applied and sequences of song units were correlated between pairs of hydrophones to localize individual humpback whales with a high degree of spatial accuracy. [Note: key components of this analysis tool were funded by the U.S. Navy’s Living Marine Resources Program]

[6d] Classification Analysis of Delphinid Whistles Recorded with PMRF Hydrophones [Oswald 2015]

Delphinid sounds recorded at PMRF were attributed to false killer whales in the absence of visual validation, since tagged false killer whales were present on the range when the sounds were recorded. In order to confirm these sounds were made by false killer whales and not by another species also present on the range at the time, a classification analysis will determine the species of delphinid whistles recorded with PMRF hydrophones. In addition to classifying whistles in the recordings, all whistles, clicks, and burst pulses in the recordings have been manually annotated. These annotations provide data that can be used to test and compare algorithms for the automated detection of sounds produced by delphinids. Results are not yet available for this project.

2.2 Results: Progress Made on 2014 HRC Monitoring Projects

Results and key conclusions from the 16 HRC monitoring projects are summarized below. **Figure 4** shows sightings, survey effort, and passive acoustic instrument locations from field projects executed in 2014. Notable outcomes for each project are listed in **Table 2**, found at the end of this section.

Table 2. Quick-look summary of progress made in 2014 on HRC monitoring questions.

Monitoring Questions	Progress Made in 2014 and Notable Outcomes
What species of beaked whales (*Ziphius*/ *Mesoplodon*) are heard in and around the Niihau area of the HRC?	• Cuvier's and Blainville's beaked whales were detected in only 16 of over 3,000 recordings (of over 277,000 recordings total) made by EARs deployed at Niihau and Kaula from 2011 to 2013 **[1a].**
What is the seasonal occurrence of baleen whales (minke, fin, possibly sei) heard in the HRC around the Niihau area?	• EAR recordings indicated that minke and fin whales occur around Niihau and Kaula in winter through spring only. No sei whales were detected acoustically **[1a].**
What is the occurrence of sperm whales heard in the HRC around the Niihau area?	• PAM conducted from 2011 to 2013 at Niihau and Kaula revealed the presence of sperm whales, but there were few detections and no significant seasonal or diel patterns were evident **[1a].**
What species of delphinids occur in the HRC around the Niihau area?	• Analysis of EAR data using ROCCA revealed the presence of short-finned pilot whales, false killer whales, pantropical spotted dolphins, rough-toothed dolphins, bottlenose dolphins, and spinner/striped dolphins around Niihau and Kaula **[1a].**
Do beaked whale (*Ziphius*/*Mesoplodon*), baleen whale (minke, fin, possibly sei), sperm whale, and delphinid detection rates vary before, during, and after MFAS detections?	• Low acoustic encounter rates for beaked whales, sperm whales, minke whales, and fin whales in EAR recordings precluded a meaningful analysis of potential effects of MFAS on these species. For dolphins heard before, during, and after MFAS, there were no statistically significant differences in acoustic encounter rates for delphinids as a whole, but when data were stratified, statistically significant differences were evident in encounter rates/durations before, during, and after MFAS for rough-toothed dolphins, low-frequency whistling species, and spinner/striped dolphins **[1a].**

Monitoring Questions	Progress Made in 2014 and Notable Outcomes
What are the spatial movement patterns and habitat use (e.g., island-associated or open ocean, restricted ranges v. large ranges) of species that are exposed to MFAS and how do these patterns influence exposure and potentially response?	• A false killer whale tagged at PMRF in July 2013 showed strong island-associated movements post-tagging, and passed through the range twice during a U.S. Navy training event involving MFAS **[2a].** • The R/V *Searcher* crew visually validated four species that were acoustically detected by the M3R team. On two occasions, the R/V *Searcher* vectored the tagging boat towards sightings that were not detected acoustically by the M3R team, resulting in the successful deployment of two satellite tags. Nevertheless, the use of the R/V *Searcher* platform was determined to not be cost-effective overall **[2b].** • Short-finned pilot whales belonging to certain social groups are more likely to be exposed to MFAS than others. The satellite-tag track for a Blainville's beaked whale is the first detailed movement data available for this species around Kauai and Niihau **[2c].**
What are the estimated received levels of MFAS to which marine mammals are exposed during anti-submarine warfare training, and what, if any, behavioral effects result at various levels?	• Sperm whales were sighted for the first time during SCC aerial ship-follow surveys for marine mammals. RLs during the ASW training event were estimated for this species, as well as for humpback whales and short-finned pilot whales and ranged from 158 to 174 dB re: 1µPa **[3a].** • Minke whale boing call counts decreased in the presence of MFAS. There were fewer minke whale calls (and resultant localizations) during 'phase B' training activities (use of MFAS) when compared with the periods prior to use of MFAS **[3b].** • Blainville's beaked whale foraging dive rates decreased during periods of MFAS transmission. There were more dives detected prior to MFAS activity than during and after. Data indicate that beaked whale dives continued to occur at PMRF while MFAS activity was occurring, although in reduced numbers **[3c].**
Do marine mammals strand along shorelines of the Main Hawaiian Islands within one week following U.S. Navy training?	• No stranded or near-stranded marine mammals or sea turtles were observed during more than 3,200 km of aerial shoreline surveys following three naval training events involving MFAS **[4a** and **4b].** • Detailed Hawaiian monk seal data, including identification of individuals from unique tags and markings, were collected during a ground-based survey at Niihau, which was conducted simultaneously with an aerial shoreline survey to compare the efficacy of each method in detecting strandings. The ground-based survey was more effective at detecting hauled-out Hawaiian monk seals, while aerial surveys provided superior nearshore coverage of in-water sightings **[4a].**
What is the effectiveness of U.S. Navy lookouts when implementing protective measures?	• The eleventh LOE survey was performed aboard a DDG emitting MFAS, and the second such survey was performed aboard a CG. Data from these studies will be examined as a whole to determine the overall effectiveness of U.S. Navy lookouts, rather than assessing specific vessels **[5a-c].**
Which marine mammals are observed in the vicinity of ASW and UNDET training that could be exposed to U.S. Navy sound sources?	• The only marine protected species observed in the vicinity of UNDET in April 2014 was a green turtle. UNDETs were delayed for approximately an hour until the turtle left the 700-yard (640-m) exclusion zone **[5d].**

Monitoring Questions	Progress Made in 2014 and Notable Outcomes
How does our ability to address question of exposure (integrating propagation models and animal occurrence) vary with species/species groups?	• A novel, integrated approach used PMRF data to estimate RLs for three species of tagged marine mammals: bottlenose dolphin, roughed-toothed dolphin, and short-finned pilot whale. Rough-toothed dolphins were exposed to estimated RLs of: 130 to 144 dB re: 1µPa RMS (hereafter dB); 149 to 168 dB for a bottlenose dolphin, and 141 to 162 dB for a short-finned pilot whale. The bottlenose dolphin showed no large-scale movements out of the area during MFAS exposures despite relatively high RLs, and the short-finned pilot whale actually moved towards areas of higher exposures **[6a].**
How well is baseline occurrence (distribution, density and habitat use) known/defined (short- to medium-term) across species groups?	• Bryde's whales were detected on PMRF using burst-type calls attributed to the species. Over 400 calls were tracked; Individuals exhibited a range of swim speeds. These encounters provide new information about this species' use of PMRF and its distribution and acoustic behavior in general **[6b].** • An automated method was developed to track humpback whales at PMRF using song units attributable to individual animals. This method processes data five times faster than real-time with a predicted high level of spatial accuracy **[6c].**

Key: ASW = anti-submarine warfare; CG = guided missile cruiser; dB re: 1µPa = decibel(s) referenced to 1 micro Pascal; DDG = Guided Missile Destroyer; EAR = ecological acoustic recorder; HRC = Hawaii Range Complex; km = kilometer(s); LOE = lookout effectiveness; m = meter(s); MFAS = mid-frequency active sonar; PAM = passive acoustic monitoring; PMRF = Pacific Missile Range Facility; RL = received level; RMS = root mean square; ROCCA = Real-time Odontocete Call Classification Algorithm; SCC = Submarine Commanders Course; UNDET = underwater detonation; U.S. = United States; v. = versus..

2.2.1 Project 1: Analysis of Existing Passive Acoustic Data

Monitoring Question: What species of beaked whales (*Ziphius/Mesoplodon*) are heard in and around the Niihau area of the HRC?

[1a] Lammers et al. (2015)

Beaked whales, including species confirmed to occur in Hawaiian waters, produce echolocation clicks, or short-duration pulsed signals, which are used to locate prey and for conspecific communication. These animals produce distinctive echolocation clicks, which allow for the use of automated algorithms to classify the signals.

The initial analysis of the PAM data collected around Niihau and Kaula used the U.S. Navy-developed Class-Specific Support Vector Machine (CS-SVM) to classify detected clicks to a species class based on acoustic properties. Upon completion of this effort, several issues were identified with the way the ground-truthing results were initially interpreted on a click-by-click basis. Results were then re-interpreted by looking at sequences of clicks to account for the context of surrounding classifications, which is an indication of the reliability and accuracy of detector output for a given species class. After reinterpreting a subset of the results and examining additional recordings, it was determined that clicks from both Cuvier's beaked whales and Blainville's beaked whales were present in only a small number of recordings (only 16 of over 3,000 recordings reviewed, of over 277,000 recordings total). Unfortunately, the number of detections in the reinterpreted data was too low to make any inferences regarding distribution patterns and/or seasonal occurrence of these species.

Monitoring Question: What is the seasonal occurrence of baleen whales (minke, fin, possibly sei) heard in the HRC around the Niihau area?

[1a] Lammers et al. (2015)

Automated analysis of EAR recordings reported detections of blue, fin, humpback and minke whale calls. Follow-up analysis using manual techniques to ground-truth the automated detectors, indicated that the two blue whale automated detections were false positives, and no blue whale sounds were detected in additional recordings that were reviewed manually. However, fin, minke, and humpback whale sounds were confirmed to be present in the recordings, and manual analyses were conducted on a subset of data to note the seasonal occurrence patterns of these baleen whale species. Humpback whales were the most predominant species and were detected in December to May, followed by minke whales, which were detected from January to April. Fin whales had the fewest acoustic detections; this species appears to be rare in EAR recordings made in this part of the Main Hawaiian Islands. Furthermore, the results indicated that minke and fin whales occur around Niihau and Kaula only in the winter through spring months. No sei whales (*Balaenoptera borealis*) were detected in the acoustic data.

Monitoring Question: What is the occurrence of sperm whales heard in the HRC around the Niihau area?

[1a] Lammers et al. (2015)

Like beaked whales, sperm whales (*Physeter macrocephalus*) produce very distinctive clicks that are generally lower in frequency and relatively long in duration compared to all other echolocating whale and dolphin species. Sperm whales were detected in the EAR recordings made at Niihau and Kaula at all EAR locations; however, there were relatively few acoustic detections of this species, and no significant seasonal or diel patterns were evident. Overall, sperm whales occurred sporadically at the monitored locations, with multiple weeks often elapsing between encounters. Sperm whales were detected using both manual and automated techniques.

Monitoring Question: What species of delphinids occur in the HRC around the Niihau area?

[1a] Lammers et al. (2015)

Delphinid species that occur around the Hawaiian Islands produce whistles that may be diagnostic of species identity. Delphinid whistles were recorded at each of the EAR sites and Real-time Odontocete Call Classification Algorithm (ROCCA) was used to determine species identity for encounters that met the classifier's requirements. Of the species acoustically validated in Hawaii, ROCCA is able to classify whistles into the following designations: short-finned pilot whale, false killer whale, pantropical spotted dolphin (*Stenella attenuata*), rough-toothed dolphin (*Steno bredanensis*), bottlenose dolphin, and spinner/striped dolphins (*Stenella longirostris*/*Stenella coeruleoalba*). All six of these species were detected at each EAR during at least one deployment. The northwest side of Niihau had the highest mean encounter rate per day, followed by Pueo Point, Southwest Niihau, and Kaula. The greatest number of ROCCA classifications was for spinner/striped dolphins, followed by bottlenose and rough-toothed dolphins. A smaller number of pantropical spotted dolphins, false killer whales, and short-finned pilot whales were also classified. A seasonal trend of occurrence was evident for all delphinid species classified, with lower levels of acoustic activity in winter and spring compared to summer and fall. Two species, false killer whale and short-finned pilot whale, were detected in summer/fall but not in winter and spring. In addition, a strong diel pattern was observed for the spinner/striped dolphin class and all acoustic encounters pooled together (which were dominated by the spinner/striped class), with the majority occurring during nighttime hours. This pattern is consistent with the known pattern of spinner dolphin behavior in the Main Hawaiian Islands, characterized by quiet daytime resting periods and nighttime foraging that is associated with increased vocal activity. Vocalizations from other ROCCA-classified species and low-frequency whistling species (classified manually) did not exhibit a pronounced diel trend.

Monitoring Question: Do beaked whale (*Ziphius*/*Mesoplodon*), baleen whale (minke, fin, possibly sei), sperm whale, and delphinid detection rates vary before, during, and after MFAS detections?

[1a] Lammers et al. (2015)

Six periods of MFAS exposure, consisting of MFAS occurring over two or more consecutive days, were analyzed for possible effects on acoustic encounter rates of various species. Each MFAS period was analyzed 3 days prior, the days of the MFAS broadcast, and 3 days after to assess if there was a significant change in acoustic detections of animals recorded at each of the EAR sites. While beaked whales, sperm whales, minke whales, and fin whales were recorded on the EARs, the very low encounter rates for these species precluded a meaningful analysis of the possible effects of MFAS exposure on these species' acoustic activity/occurrence at each of the recording sites. Humpback whale singing is one of the most ubiquitous underwater sounds during the winter months in Hawaii. As a result, the per-file presence/absence metrics used during this study to quantify humpback whale song were not suitable for finer-scale investigation of potential responses of humpback whales to MFAS. For dolphins heard before, during, and after MFAS, there were no statistically significant differences in acoustic encounter rates or encounter durations for delphinids as a whole. When stratified by species, site or MFAS "trial," there were some statistically significant differences in encounter rates and/or encounter durations before, during and after MFAS for rough-toothed dolphins, low-frequency whistling species, and spinner/striped dolphins. The direction of response (increase or decrease in activity) was not consistent across trials or species, and sample sizes (numbers of encounters) were generally small.

2.2.2 Project 2: Marine Species Monitoring Prior to U.S. Navy Training Events

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

[2a] Baird et al. 2014a

Prior to the July/August 2013 SCC, 671 km of small-vessel survey effort was conducted over the course of the 8-day project, with 55.1 percent of time spent within PMRF instrumented hydrophone range boundaries. A total of 33.0 hours (hr) of acoustic monitoring coincided with the small-vessel field effort. There were 18 sightings of four species of odontocetes; five of the sightings were directed by acoustic detections from the M3R real-time PAM system. Bottlenose dolphins were encountered on six occasions, spinner dolphins on three, rough-toothed dolphins on eight, and false killer whales once. Recordings on the M3R system were made for three of the four species (all but spinner dolphins) to improve species classification for future acoustic monitoring efforts. During the encounters 4,393 photographs were taken for individual identification, two biopsy samples were obtained for genetic studies, and three depth-transmitting satellite tags were deployed on two species (one false killer whale, two rough-toothed dolphins). Data were obtained from the two tagged rough-toothed dolphins for 9.9 and 13.4 days. During this period the dolphins remained associated with Niihau, with each found inside PMRF boundaries on 11 occasions, spending 34 percent and 46 percent of their time on PMRF, respectively. The tagged false killer whale was identified as part of the Northwestern Hawaiian Islands population, known from previous efforts to use the area around Kauai. Data were obtained for 21.3 days; during this period the tagged false killer whale was found inside PMRF boundaries on 17 occasions, spending 24 percent of its time on PMRF. Based on preliminary sound propagation analyses and the locations of animals tracked during this study, both of these populations are likely exposed to MFAS on PMRF, but appear to use the overall area in different ways. Thus, the likelihood of exposure to different sound levels also probably varies by species.

The most valuable data from this field effort came from the encounter with false killer whales, cued in by an acoustic detection from the M3R system. Location data from the tagged false killer whale showed a very different pattern in spatial use than had been previously documented for the false killer whales from the Northwestern Hawaiian Islands population. Prior to this effort, false killer whales from this population had been tagged on two different occasions, off Nihoa in 2010 (Baird et al. 2013a), and off Kauai in June 2012 (Baird et al. 2013b). The two previous tagging occasions were of individuals from at least two different social groups, although movement patterns were generally similar, with broad-scale movements from Kauai/Nihoa to Gardner Pinnacles (Baird et al. 2013c, 2013a). The individual tagged in July 2013 was from the same social group as at least two of the individuals tagged in July 2012, yet remained associated with the Kauai and Niihau area for the entire 21 days post-tagging. The tagged individual remained associated with the island before, during, and after the SCC held in August 2013, and passed through PMRF twice during the SCC.

[2b] Deakos and Richlen 2015

The R/V *Searcher* large-vessel survey contributed to the visual validation of four species (bottlenose dolphin, Blainville's beaked whale, rough-toothed dolphin, and short-finned pilot whale) that were acoustically detected by the M3R team. On two occasions, the R/V *Searcher* vectored the tagging boat towards two sightings that were not detected acoustically by the M3R team, resulting in the successful deployment of two satellite tags. Eighty-one percent (n=25) of the marine mammal sightings aboard the R/V *Searcher* were either on the range, or within 1 km of the range perimeter; 13 of those 24 sightings were identified to species: bottlenose dolphin (n=6), short-finned pilot whale (n=4), Blainville's beaked whale (n=1), and rough-toothed dolphin (n=2) (**Figure 6**). Eight of the sightings were visual validations of acoustic detections made by the M3R team, of four different species: Blainville's beaked whale, short-finned pilot whale, rough-toothed dolphin, and bottlenose dolphin. Communications between the R/V *Searcher*

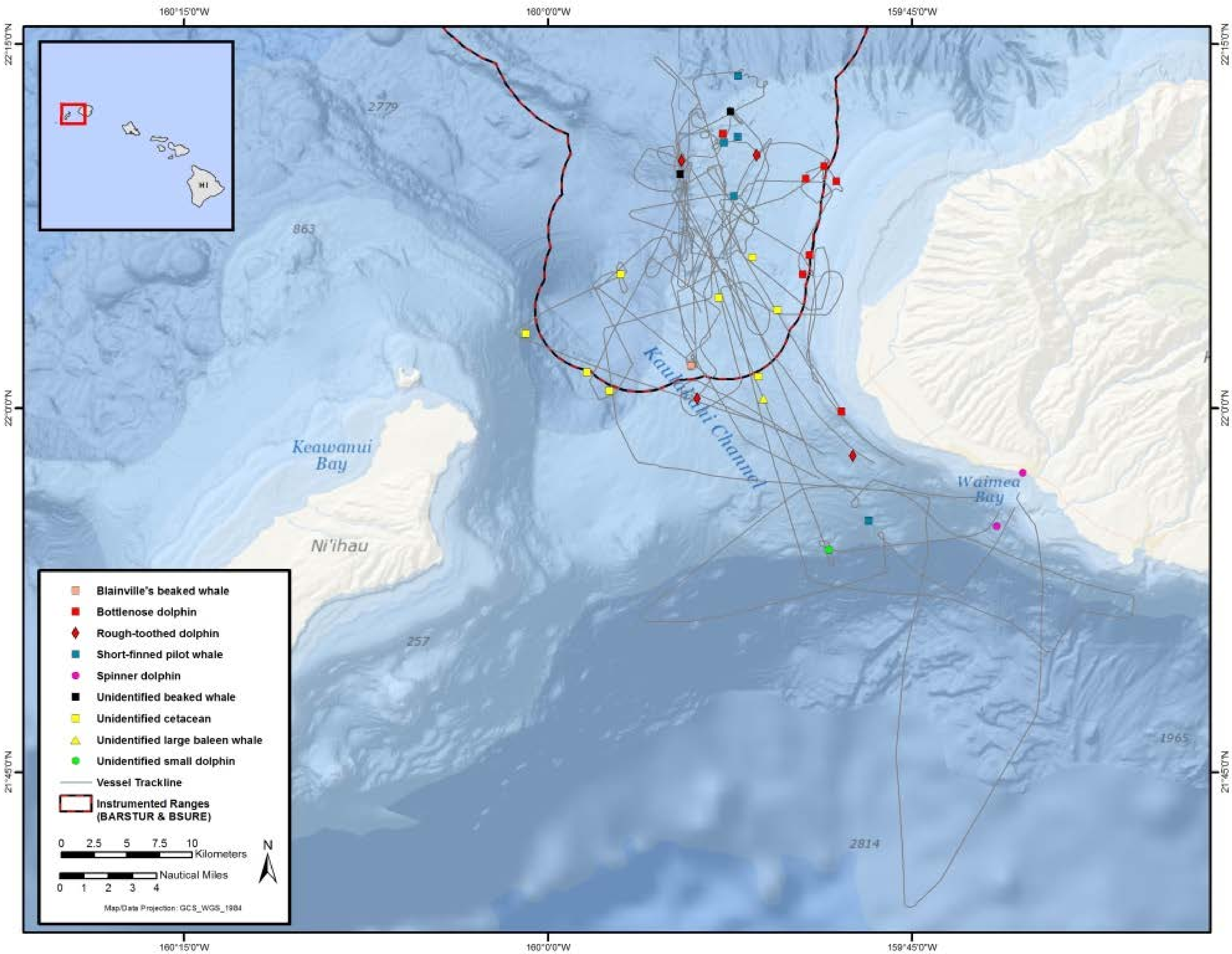

Figure 6. Sightings and effort from the R/V *Searcher* large-vessel survey, February 2014 (Deakos and Richlen 2015 [2b]).

crew and the tagging crew facilitated tagging operations, and 12 tags were deployed on four species—six short-finned pilot whales, two bottlenose dolphins, two rough-toothed dolphins, and two Blainville's beaked whales (although data were obtained from only one of the two Blainville's beaked whales' tags; see Baird et al. 2014b **[2c]** for details).

A total of 1,970 photographs were taken of three different species for photo-identification. The majority (63 percent) were taken of short-finned pilot whales, followed by rough-toothed dolphins (31 percent), and bottlenose dolphins (6 percent). The sightings per unit effort (SPUE) was calculated as the total number of marine mammal sightings (*n*=31) divided by the total survey effort (74.40 hr or 933 km). The SPUE for marine mammals excluding humpback whales was 0.42 sightings per hr or 0.03 sightings per km of effort. The Beaufort Sea State (BSS) ranged from 1 to 5, and sightings were made almost equally in BSS 2, 3, and 4.

[2c] Baird et al. 2014b

Prior to the SCC in February 2014, there were 1,287 km (66.3 hr) of small-vessel survey effort over the course of the 10-day project, with 44.6 percent of search time (29.6 hr) spent within PMRF instrumented hydrophone range boundaries. A total of 81.7 hr of acoustic monitoring was undertaken during the field effort. There were 26 sightings of five species of odontocetes; six sightings were directed by acoustic detections from the M3R real-time PAM system. Bottlenose dolphins were encountered on eight occasions, spinner dolphins on seven, short-finned pilot whales on five, rough-toothed dolphins on two, and Blainville's beaked whales once. Recordings on the M3R system were made for four species (all but spinner dolphins) to improve species classification for future acoustic monitoring efforts. During the encounters 10,928 photographs were taken for individual identification, six biopsy samples were obtained for genetic studies, and 12 satellite tags were deployed on four species—six short-finned pilot whales, two bottlenose dolphins, two rough-toothed dolphins, and two Blainville's beaked whales (although data were obtained from only one of the two). The Blainville's beaked whale was tagged off PMRF, but over an 8-day period, the tagged animal moved onto the range three times and spent an estimated 20.5 percent of its time on PMRF. The tagged individual remained associated with the island slopes (median depth of locations = 961 meters [m]), and remained within 83 km of the tagging location. Although both of the tagged rough-toothed dolphins remained associated with the islands (median depths of 1,463 and 1,961 m), one individual data obtained for bottlenose dolphins, rough-toothed dolphins, and short-finned pilot whales off Kauai indicate that core ranges (i.e., the 50 percent kernel density polygons) for all three species overlap with PMRF. Continued collection of movement and habitat use data from all species will allow for a better understanding of the use of the range as well as provide datasets that can be used to estimate RLs at animal locations and examine potential responses to MFAS exposure.

2.2.3 Project 3: Marine Species Monitoring at PMRF during U.S. Navy Training Events

Monitoring Question: What are the estimated received levels of MFAS to which marine mammals are exposed during anti-submarine warfare training, and what, if any, behavioral effects result at various levels?

[3a] Mobley et al. 2015

During aerial surveys conducted in conjunction with an SCC training event, the aircraft conducted elliptical orbits ahead of a Navy warship 11 hr, 51 percent of the total 21.4 hr of flight time. The majority of effort (90 percent) was spent viewing in BSS 3 or better resulting in the focal-following of eight sightings (three sperm whale, three short-finned pilot whale, and two humpback whale), six of which (three sperm whale, one short-finned pilot whale, and two humpback whale, **Figure 7**) were determined to be within 5 km of the ship transmitting MFAS, permitting the estimation of MFAS RLs at the animal's location and behavioral response. The only videotaped behavioral focal-follow sessions involved the three sightings of short-finned pilot whales (group sizes of 17, 25, and 25). The duration of the taped sessions was a total of 44 minutes (min). Observers attempted to perform taped sessions of the sperm whale sightings, but the sperm whales were typically at the surface for 3 to 5 blows, dove, then remained underwater for 30 to 45 min, an interval too long for behavioral assessment. The two remaining attempts involved sessions with single humpback whales. One was curtailed due to low fuel and the other when the whale could not be resighted. Nevertheless, sound exposure levels (SELs) were estimated for all eight sightings detected within 5 km of the ship, and ranged from 158 to 174 decibels referenced to 1 micro Pascal (dB re: 1µPa). No instances of unusual behavior or signs of distress were observed throughout the three days of surveys, including for the overall 11 sightings (81 percent of which were of humpback whales).

[3b] Martin et al. 2014

Based upon analysis of the available data from February 2011, February 2012, and February 2013, minke whale boing call counts decrease in the presence of MFAS. There were fewer minke whale boings (and resultant localizations) during 'phase B' (surface ship training with MFAS) training activities when compared with the periods prior to ship training with MFAS. Estimated minimum density of calling minke whales within each year was higher for the 'before' data compared to the 'phase B' data, and this difference was statistically significant in 2011, 2012 and 2013. However, preliminary analysis of data from the February 2014 training event indicated that the proximity of surface ships to calling whales can result in cessation of calling even when no MFAS activity is occurring. The minimum densities of calling minke whales were different from year to year, with 2011 the highest. For 2011, the estimated minimum density of calling minke whales during the 'phase B' period was 0.69 whales per 3,780 square kilometers (km^2) (the dimensions of the study area, confidence interval [CI] 0.27 to 1.8), which was depressed compared to the 2011 before period with 3.64 whales per 3,780 km^2 (CI 3.31 to 4.01). A similar trend was observed for the 2012 data.

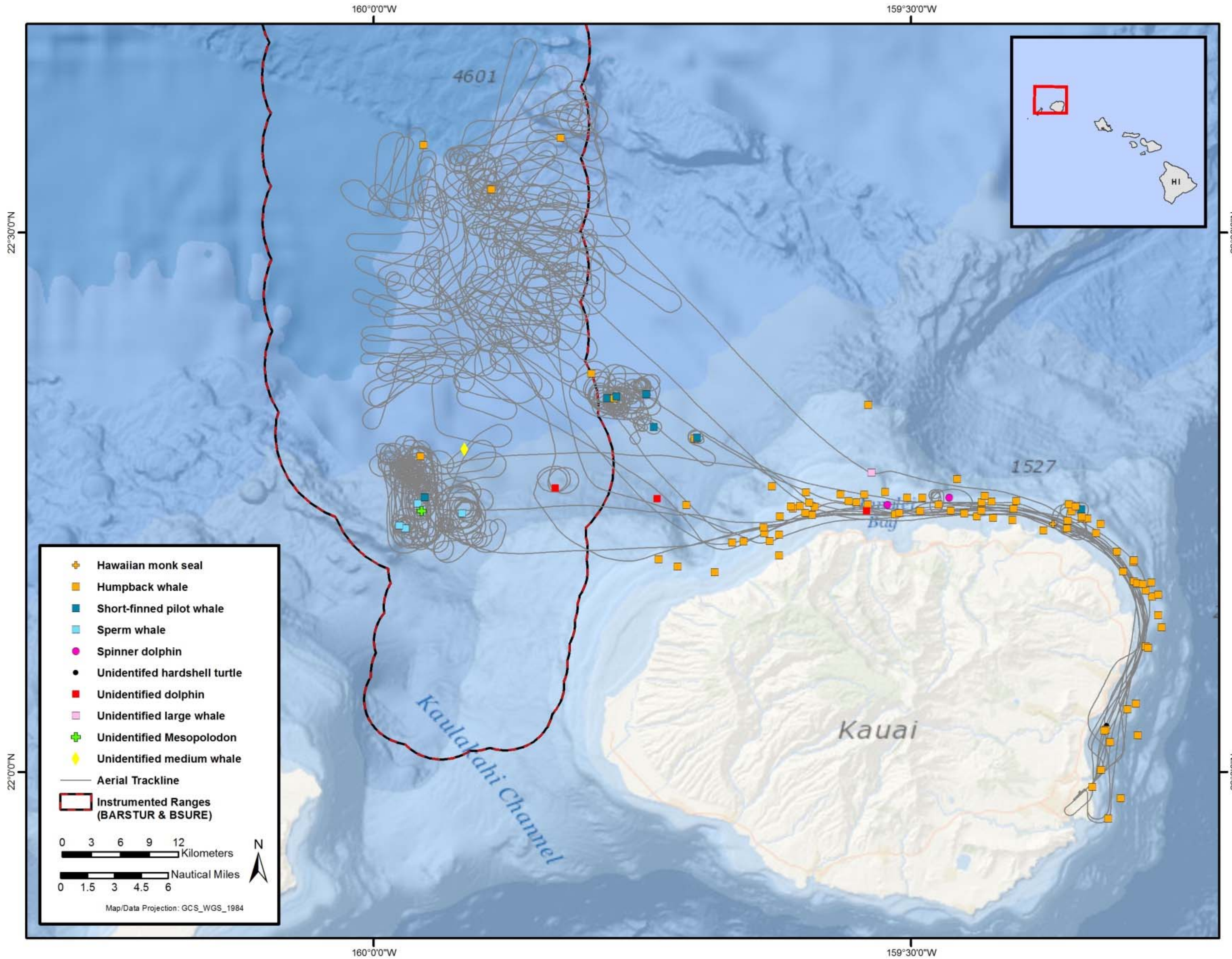

Figure 7. Sightings and effort from SCC ship-follow aerial (fixed-wing) surveys, February 2014 (Mobley et al. 2015 [3a]).

[3c] Henderson et al. 2015

Beaked whale dive behavior, in conjunction with six MFAS training events from 2011 to 2013, was analyzed. Beaked whale foraging dive rates decreased during periods of MFAS transmission. Combined acoustic data from six training events at PMRF contained evidence of 446 Blainville's beaked whale dives detected before training, 208 dives during 'Phase I' periods (during ship activity but MFAS absent), 158 during all 'Phase II' periods (with MFAS), 313 after the training events, and 158 over two weekend periods in 2013. This equated to an overall mean of 1.5 dives per hour before, 0.8 dives per hour during "Phase I,' 0.5 dives per hour during 'Phase II,' 0.8 dives per hour after, and 0.8 dives during the two between periods. Statistical analysis showed there were far more dives in the "before" period and fewer dives in the other periods than expected when the proportions are compared. These data indicate that beaked whale dives continued to occur at PMRF while MFAS occurred, although in reduced numbers.

2.2.4 Project 4: Marine Species Monitoring Following Navy Training Events

Monitoring Question: Do marine mammals strand along shorelines of the Main Hawaiian Islands within one week following U.S. Navy training?

[4a] Ampela et al. 2015

In August 2013, aerial and ground-based shoreline surveys were conducted approximately one week following an SCC at PMRF. Aerial surveys circumnavigated Kauai and Niihau by helicopter, and ground-based surveys circumnavigated Niihau only. No marine mammal strandings or near strandings were detected at either island despite 429 km of aerial shoreline effort and 87 km of ground-based survey effort. However, the ground-based survey team at Niihau encountered a Hawaiian monk seal carcass that was heavily parasitized, had been mummified and rehydrated, and likely did not die in the spot where it was found (Thomton 2015). The carcass was brought to a NMFS facility in Honolulu for necropsy. Two teeth remained in the lower jaw, analysis of which revealed that the animal was a juvenile male, approximately 2 years old, in good body condition at the time of death. X-rays revealed no evidence of bullets or fish hooks, and the cause of death was not determined (Thomton 2015).

During aerial surveys, 71 marine mammal/sea turtle sightings (334 individuals) were recorded across 429 km of shoreline effort (291 and 138 km for Kauai and Niihau, respectively). The overall encounter rate for aerial surveys was 0.17 sightings per km. The most commonly observed animal group was the Hawaiian monk seal, followed by unidentified sea turtles. Ninety-four percent (*n*=51) of monk seals were hauled out on the beaches of Niihau, which is consistent with their reported preference for secluded areas in the Main Hawaiian Islands (Baker and Johannos 2004). During ground-based surveys at Niihau, using a combination of vehicles and horseback, 31 sightings were recorded. All but two of these were of Hawaiian monk seals (29 sightings of 43 individuals); the other two sightings were of spinner dolphins (*n*=40 individuals) and an unidentified cetacean (*n*=1 individual). The overall encounter rate for the ground-based survey was 0.35 sightings per km.

On 20 August, when both aerial- and ground-based surveys were conducted, ground teams recorded more Hawaiian monk seal sightings than did aerial observers (*n*=29 and 11 sightings, respectively) as well as more sightings overall (31 v. 12 sightings, respectively). The ground-based crew also found a monk seal carcass, which the aerial team did not detect. Even from the ground, monk seals were often difficult to distinguish when on dark-colored reefs and lava outcroppings that characterize the northern and western shorelines of Niihau. Observers on the ground were better able to distinguish seals in these areas than observers in the aircraft. Ground-based observers also encountered two monk seals with identifying markings. One was an adult female seal, part of a mother-pup pair, with an “N14” bleach mark on her flank. Another monk seal was observed with an orange flipper tag that read “7GY.” Tag identification revealed this animal to be an adult male, also referred to as T21M, which was relocated to the Main Hawaiian Islands from Laysan Island in the Northwestern Hawaiian Islands (Littnan et al. 2012). As part of a U.S. Pacific Fleet-funded study of Hawaiian monk seal habitat use and behavior in the HRC, T21M was captured on 15 July 2011 on Oahu and instrumented with flipper tags (7GY/7GZ) as well as a cell phone tag (#11813), which recorded this animal’s movements over the course of several months (Littnan et al. 2012). Tag data revealed that T21M traveled extensively amongst Oahu, Kauai, and Niihau, with dive depths ranging from 17 to 38 m and durations of 6 to 8 min (min) (Littnan et al. 2012). Overall, ground-based teams had higher-resolution coverage of shoreline areas, particularly of Hawaiian monk seals, whereas aerial survey teams were better at detecting inshore cetacean sightings. The helicopter survey circumnavigated Niihau in 47 min, whereas the ground-based crew took more than 8 hr to circumnavigate the island; the timespan for observations could very well factor into the amount of animals observed. Overall, the ground-based survey was more effective at detecting hauled-out Hawaiian monk seals, whereas aerial surveys provided superior nearshore coverage of in-water sightings.

[4b] Mobley and Deakos 2015

Aerial shoreline surveys were conducted in late January/early February 2014 following a Koa Kai training event, and in August 2014 following the RIMPAC exercise. Both shoreline surveys were conducted within a week following each training event. The first survey circumnavigated Kauai on 31 January, and again on 05 February 2014, while the second survey circumnavigated Oahu and Maui County (Maui, Molokai, Lanai, and Kahoolawe) on 01 August and again on 04 to 06 August 2014 (**Figures 8 and 9**). All surveys involved monitoring for stranded or near-stranded marine mammals and sea turtles along the shoreline by helicopter. Over the 6 days of surveys, no stranded animals were seen despite a total of 134 sightings in 412 km of shoreline effort after the January Koa Kai training event, and 185 sightings in 2,748 km of shoreline effort after the RIMPAC exercise. Most of the sightings (76 percent) were unidentified sea turtles. A considerable number of hauled-out Hawaiian monk seals were observed, suggesting that a freshly stranded marine mammal likely would have been detected.

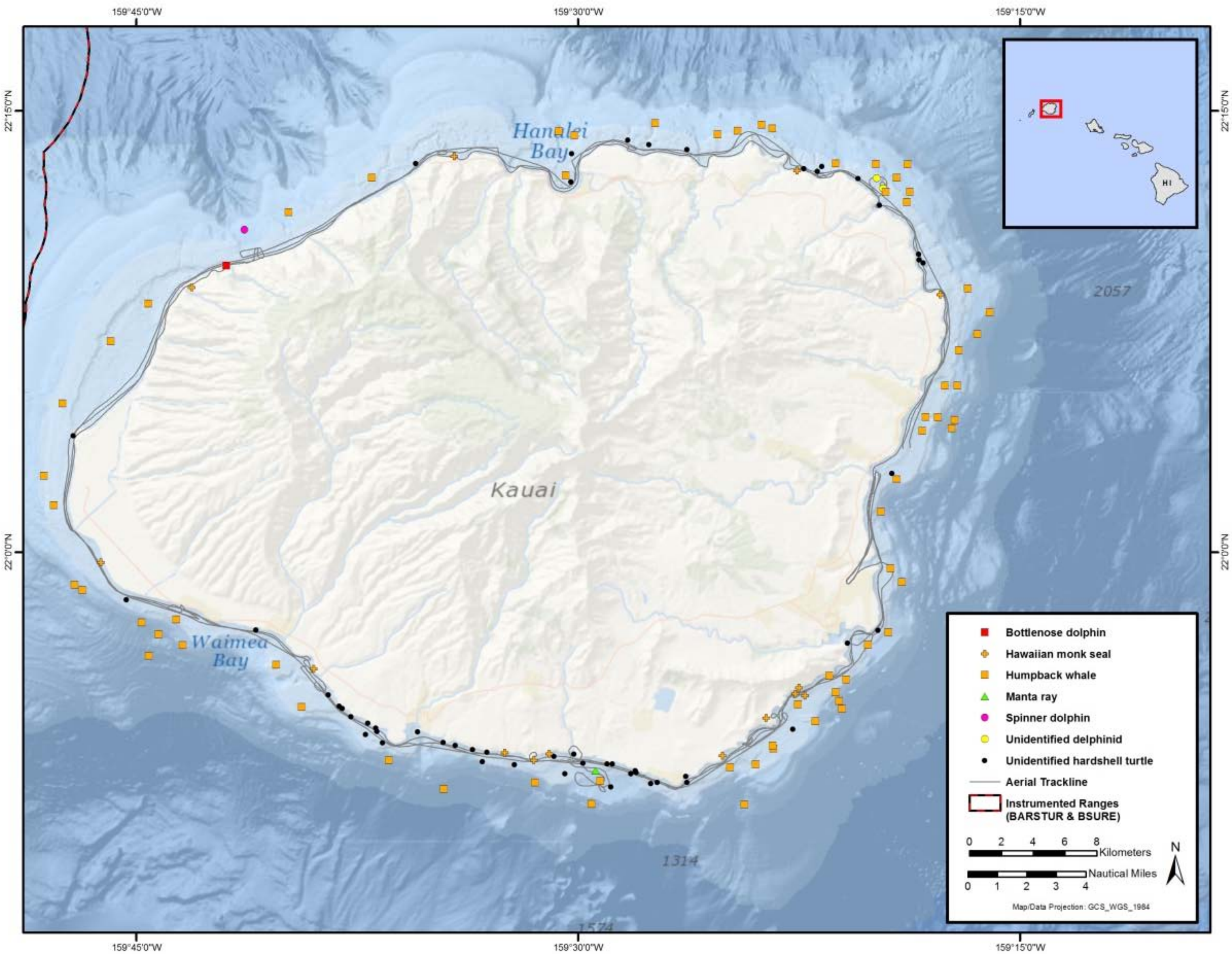

Figure 8. Sightings and effort from shoreline aerial (helicopter) surveys at Kauai, January/February 2014 (Mobley and Deakos 2015) [4b].

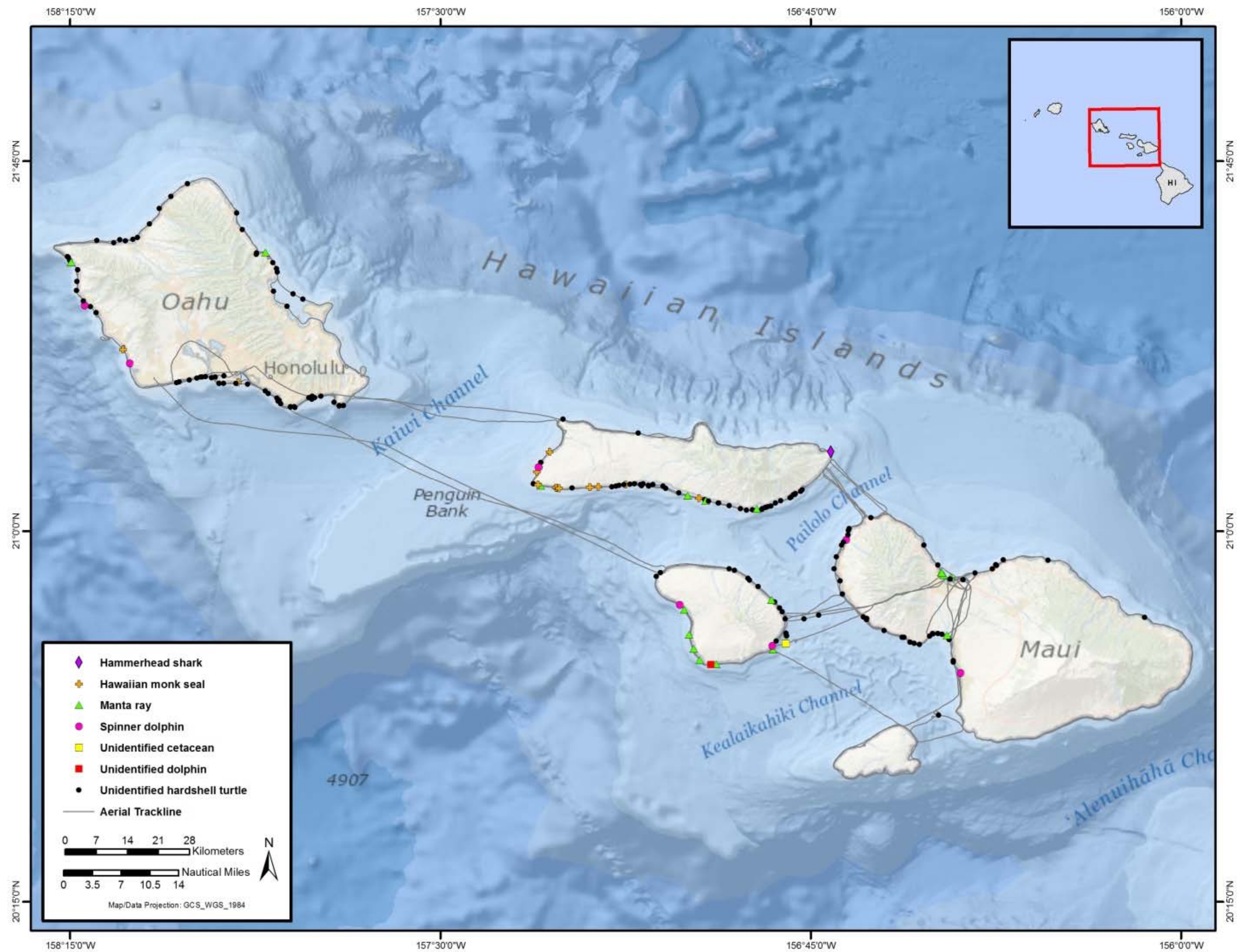

Figure 9. Sightings and effort from shoreline aerial (helicopter) surveys at Oahu and Maui County, August 2014 (Mobley and Deakos 2015) [4b].

2.2.5 Project 5: Marine Species Observers Embarked on U.S. Navy Assets during Anti-submarine Warfare Training and Underwater Detonation Training and Testing

Monitoring Question: What is the effectiveness of U.S. Navy lookouts when implementing protective measures?

[5a] Vars et al. 2014

MMOs embarked on a U.S. Navy guided missile destroyer (DDG-J) in August 2013 during an SCC in the HRC. The MMOs followed a prescribed protocol to collect data that will be pooled with other embarks and analyzed to assess the effectiveness of U.S. Navy lookouts. In addition, MMOs recorded marine mammal and sea turtle sightings in order help determine the species and populations that are exposed to U.S. Navy training events in the HRC. Thirty-six hr and 16 min of effort was conducted to search for marine species during the training event. Except for the last hour of the last day, each observation day was spent in BSS 4 or greater, which amounts to inferior environmental sighting conditions. In total, five unique sightings of at least 17 individual marine mammals and sea turtles were recorded during the 5 days of observation. Only one trial was successfully conducted during the event, defined as a sighting which was recorded by the MMO team before the watchstander team. One of the five sightings was available for a study trial (20 percent), or an average rate of 0.028 trials per hour of effort across all 5 days of observation. Of these five sightings, two species were positively identified. Visual sightings included one unidentified small marine mammal, a group of up to 10 short-finned pilot whales, two unidentified sea turtles, and one green turtle (*Chelonia mydas*). The fifth day of the effort had the greatest frequency of unique sightings, 1.17 sightings per hour (hr) of effort. For each sighting, the MMO team recorded the bearing and distance of the animal to DDG-J, which can later be used to determine the level of exposure a marine mammal or sea turtles may experience during MFAS. This event was the tenth aboard a DDG in which data were collected to determine lookout effectiveness; data will be combined with future monitoring efforts in order to determine the effectiveness of U.S. Navy lookouts as a whole, rather than specific to each vessel.

[5b] Shoemaker et al. 2014

MMOs embarked on a U.S. Navy guided missile destroyer (DDG-K) from 25 January through 01 February 2014 during a Koa Kai training event. The MMOs followed a prescribed protocol to collect data that will be pooled with other embarks and analyzed to assess the effectiveness of U.S. Navy lookouts. In addition, MMOs recorded marine mammal and sea turtle sightings in order help determine the species and populations that are exposed to U.S. Navy training events in the HRC. The MMO team spent 43 hr and 4 min searching for marine species during the training event. The majority of observation time was spent in BSS of 4 or greater (78 percent), although the majority of the sightings (61 percent) occurred in BSS 3. In total, 60 unique sightings of at least 107 individual marine mammals were recorded during the 7 days of observation. Study ‘trials’ were successfully conducted on all days of the event, with 56 of the 60 sightings (93 percent) available for trials, or an average rate of 1.30 trials per hr of effort across all 4 days. The average of trials per hr was skewed by the considerable increase of sightings on 31 January with 5.19 sightings per hr. Of the 60 sightings, humpback whales were the only species positively identified. Unidentified dolphins were sighted three times, and the rest of sightings were of unidentified cetaceans, the majority noted as large whales. For each sighting, the MMOs recorded the bearing and distance of the animal to the DDG-K, which can later be used to determine the RLs a marine mammal or sea turtles may experience during MFAS. This event was the eleventh aboard a DDG in which data were collected to determine lookout effectiveness; data will be combined with future monitoring efforts in order to determine the effectiveness of U.S. Navy lookouts as a whole, rather than specific to each vessel.

[5c] Dickenson et al. 2014

MMOs embarked on a U.S. Navy guided missile cruiser (CG-B) from 17 to 21 February 2014 during an SCC event in the HRC. The MMOs followed a prescribed protocol to collect data that will be pooled with other embarks and analyzed to assess the effectiveness of U.S. Navy lookouts. In addition, MMOs recorded marine mammal and sea turtle sightings in order help determine the species and populations that are exposed to U.S. Navy training events in the HRC. The MMO team spent 29 hr and 51 min searching for marine species during training. During the event, BSS ranged from 2 to 5. The majority of observation time was spent in BSS 2 or 3 (31.9 percent and 52.6 percent, respectively) which amounts to favorable environmental sighting conditions, with the majority of the sightings (66.7 percent) occurring in BSS 3. In total, 15 unique sightings comprising at least 45 individual marine mammals and sea turtles were recorded during the four days of observation. Study trials were conducted successfully on all but one day of the event, with 4 of the 15 sightings (27 percent) available for trials, or an average rate of 0.13 trials per hr of effort across all 4 days. Of the 15 total sightings, 12 were identified to species. Visual sightings included one short-finned pilot whale group, six humpback whales, one unidentified whale, one bottlenose dolphin, two unidentified dolphin groups, and four green turtles (**Figure 10**). The fourth day of the effort had the greatest frequency of unique sightings, with 1.31 sightings per hr of effort. For each sighting, the MMO team recorded the bearing and distance of the animal to CG-B, which can later be used to determine the RLs a marine mammal or sea turtle may experience during MFAS. This event was the second aboard a CG in which data were collected to determine effectiveness; data will be combined with future monitoring efforts in order to determine the effectiveness of U.S. Navy lookouts as a whole, rather than specific to each vessel.

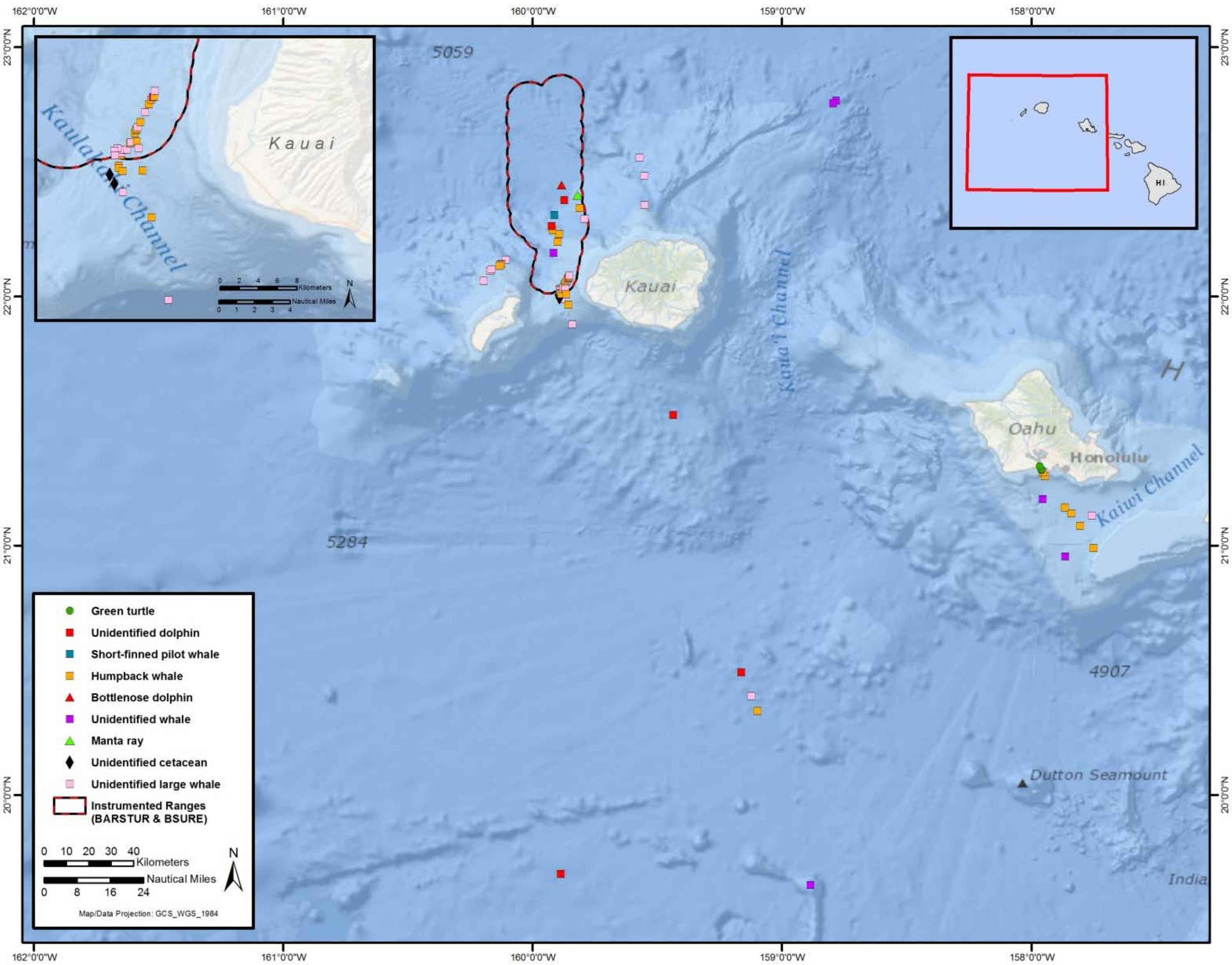

Figure 10. Sightings from two LOE studies conducted in HRC. One occurred during a Koa Kai training event in January/February 2014 (Shoemaker et al. 2014 [5b]), and the other during an SCC training event in February 2014 in HRC (Dickenson et al. 2014 [5c]). No effort from LOE surveys is displayed, since sightings data were collected from U.S. Navy warships and ship-track data are classified.

Monitoring Question: Which marine mammals are observed in the vicinity of anti-submarine warfare and UNDET training that could be exposed to Navy sound sources?

[5d] Fagan and Shannon 2015

The only marine species recorded during the UNDET training event was the green turtle. MMOs recorded a total of seven sightings of nine individuals. Upon arrival of the MMO vessel at the Puuloa Underwater Range, a green turtle was observed within the exclusion zone, and a 30-min pre-exercise visual survey commenced. Approximately 16 min into the survey period, a green turtle was again spotted inside the mitigation zone. The detonation was delayed for another 30-min period and the visual survey continued. Another green turtle was seen, this time outside of the mitigation zone, approximately 33 min later. The MMOs suspected that these three sightings were of the same animal, and no signs of distress were observed. Once the animal was observed outside the exclusion zone, the detonation was cleared to proceed, and the explosion occurred approximately 1 hr after the last sighting. The remaining sea turtle sightings were in the vicinity of the Pearl Harbor Entrance Channel buoys, well outside the mitigation range (**Figure 11**). As a continuation of a pilot study, an MMO tested the feasibility of using a dipping hydrophone to take recordings of the underwater detonation events from the MMO vessel platform during the event.

2.2.6 Project 6: Meta-analysis of HRC Monitoring and Other Existing Data Sets - Possible Inclusion of Other Existing Data in On-going Analysis

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

[6a] Baird et al. 2014c

The monitoring questions addressed in this analysis were further refined to: *(1) What were the received levels of tagged animals in the vicinity of February 2011 SCC, July/August 2011 SCC, and February 2012 SCC or other U.S. Navy training events? (2) Were there any large scale movements away from the naval training events? (3) What are the baseline short-term and long-term movement rates for tagged animals?*

Between February 2011 and February 2013, satellite-tag data were obtained from 23 individuals of four species of odontocetes: rough-toothed dolphins (*n*=8), bottlenose dolphin (*n*=6), false killer whale (*n*=3), and short-finned pilot whale (*n*=6). Initial analysis of tag and PMRF data revealed temporal and general spatial overlap for eight individuals of three species: bottlenose dolphin, short-finned pilot whale, and rough-toothed dolphin. This initial exposure analysis was restricted to one bottlenose dolphin, one short-finned pilot whale, and two rough-toothed dolphins. Based on photo-identification and association analyses, all tagged individuals were known to be from populations generally resident to the islands of Kauai and Niihau. Satellite-tagged animals were exposed to estimated RLs of: 130 to 144 dB re: 1μPa root mean square (RMS) (hereafter decibels [dB]) for two rough-toothed dolphins, ; 149 to 168 dB for a bottlenose dolphin; and 141 to 162 dB for a short-finned pilot whale.

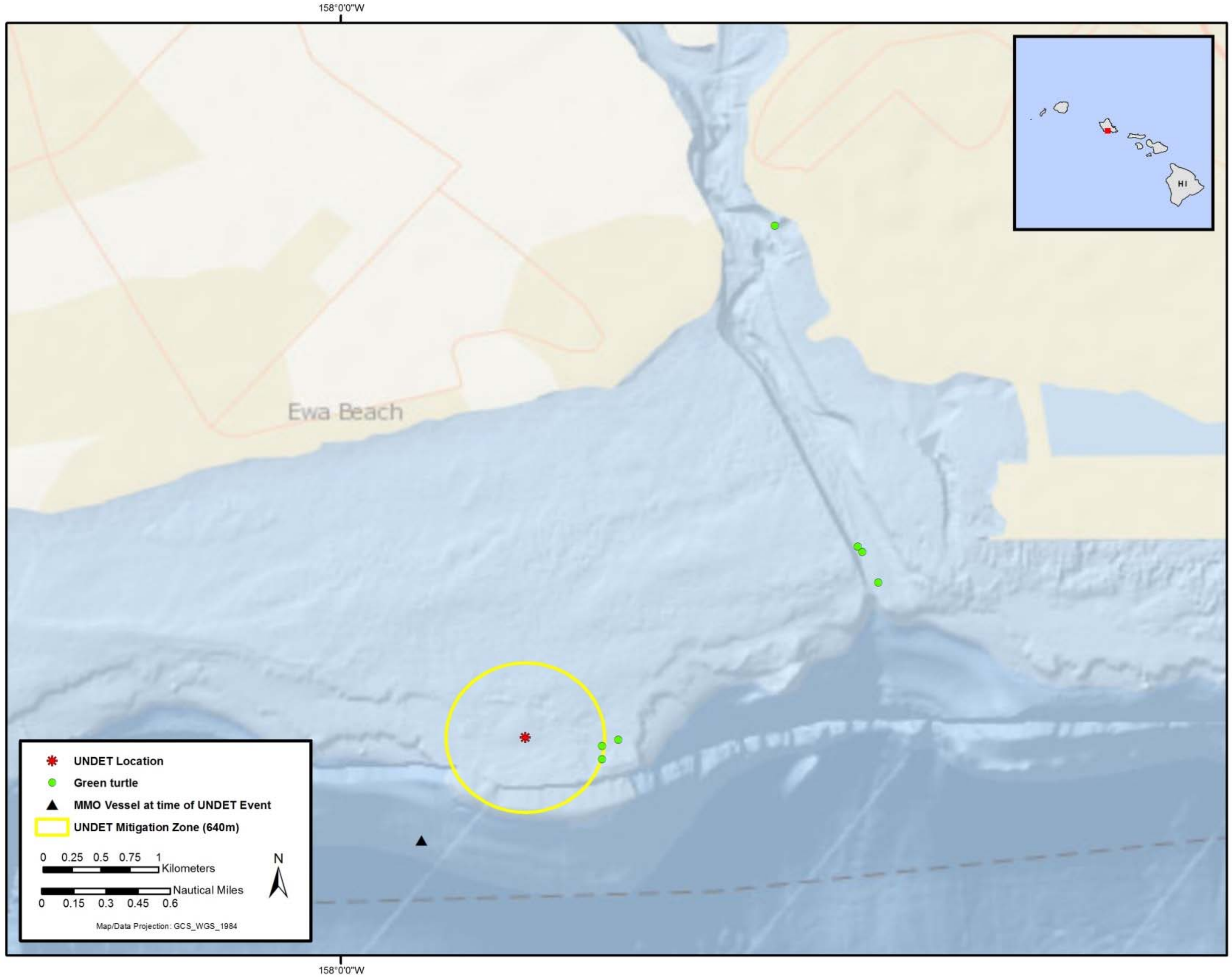

Figure 11. Sightings, monitoring vessel, and detonation locations from an UNDET conducted on 03 April 2014 in HRC (Fagan and Shannon 2015 [5d]). Sighting locations represent vessel location when animals were observed, not actual animal locations.

The bottlenose dolphin showed no large-scale movements out of the area during sonar exposures despite these relatively high predicted RLs, and the short-finned pilot whale actually moved towards areas of higher exposures during the last day of a 3-day period of regular MFAS use. Although limitations exist, this novel integrated approach of using location data from satellite-tagged individuals and modeling to estimate RLs from acoustic recordings from PMRF hydrophones is a viable and promising approach to examine both estimated exposure levels and potential large-scale movement reactions of tagged individuals.

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

[6b] Martin and Matsuyama 2015

Bryde's whales were identified by their vocalizations to use PMRF waters. Burst-type calls attributed to Bryde's whales were detected at PMRF in summer and fall. Seven separate encounters were recorded by PMRF hydrophones: one in August 2013, one in August 2014, and five in late October 2014. The burst-type pulse signals were distinct from the 20-Hz pulses and down-swept signals associated with fin and sei whales, which are typically not present in Hawaiian waters in the month of August. Over 400 calls were tracked, and traveling swim speeds were estimated to be from 4.4 to 12.2 kilometers per hour (km/hr). The range of estimated swim speeds may indicate an inherent behavioral range of the animals while traveling (i.e., potentially a 'fast travel' behavior for the animal with average speed of 12.2 km/hr). 'Traveling' and 'milling' behaviors were observed during the August encounters, which is consistent with reported visual information for Bryde's whales. These encounters provide new information not only regarding use of PMRF by Bryde's whales, but also their distribution and acoustic behavior in general.

Long-term recordings at PMRF only commenced in late August 2014, but already have provided value in allowing for the detection of Bryde's whales in late October 2014. Five animal tracks were recorded over a 2-day period (**Figure 12**), followed by an absence of detections over the next 4 days. This reflects the relatively low density of the species at PMRF and the need for more continuous-type monitoring to understand how often Bryde's whales frequent the area.

[6c] Helble et al. 2015a

Automated TDOA methods were used to process 40 days of data on PMRF recorded from December through May, spanning 2011 to 2014. A total of 3,500 valid localizations was computed over the course of 3.5 hr. Thirty-one unique humpback tracklines were found in the recordings. Manual inspection of the TDOA cross-correlations revealed all calling humpback whales in the vicinity were localized consistently, with an incorrect localization rate of 2 percent or less. A surprisingly large proportion of detected units originated from off-range locations. While exact position fixes cannot be calculated, analysis suggests these calls originated from near-shore and potentially propagated out to 60 km in some cases. If analysis was performed on single hydrophones within the range, the animal density could easily be overestimated in the study area, due to the non-random distribution of animals. This automated technique proved to be effective for localizing humpback whale vocalizations five times faster than real-time analysis, and with a high predicted level of spatial accuracy.

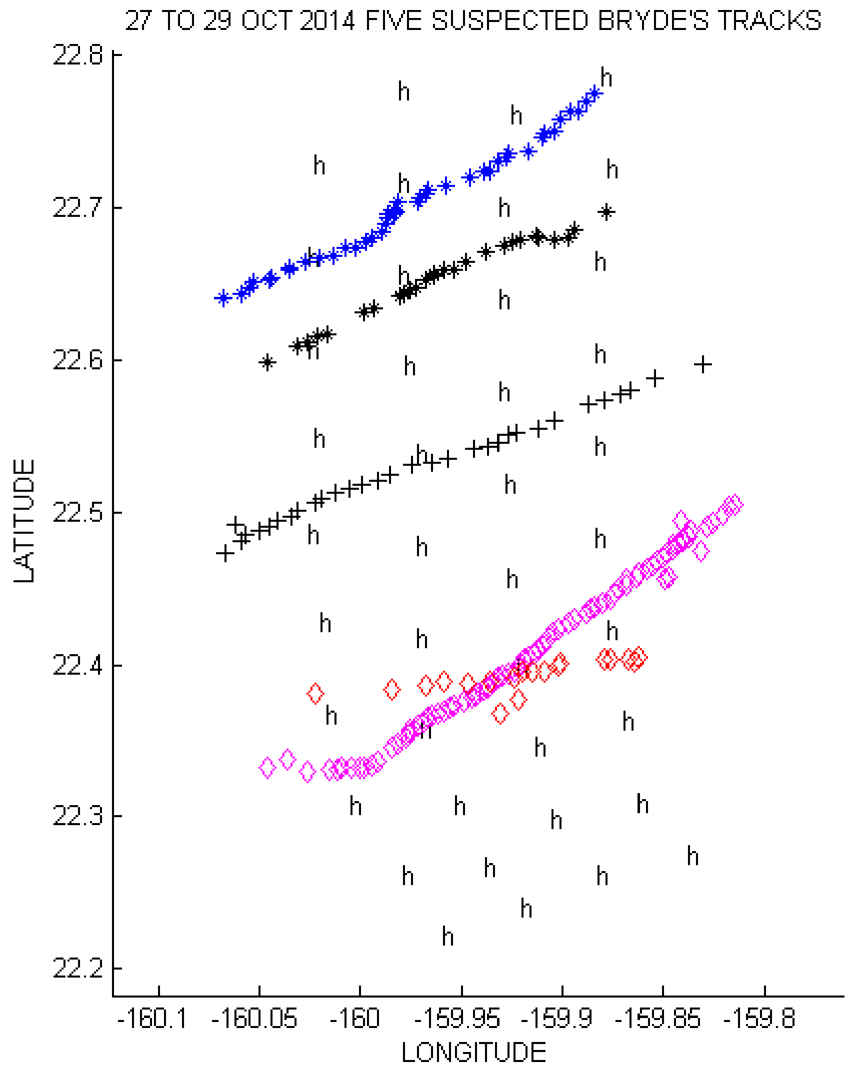

Figure 12. Automatically-generated tracks for five Bryde's whales (*Balaenoptera edeni*) at PMRF from 27 to 29 October 2014 (Martin and Matsuyama 2015 [6b]).

2.3 Cumulative Comparison of 2014 HRC Monitoring Data to Previous Years

In HRC, in 2014 there has been a continued effort to address intermediate scientific objectives by increasing understanding of the spatial movement patterns and habitat use of species which may be exposed to MFAS, estimating RLs on marine mammals during naval training events, detecting behavioral response, or lack thereof, of marine mammals to MFAS, and developing passive acoustic techniques leveraging PMRF data.

In 2013, evidence pointed to a demographically isolated population of bottlenose dolphins off Kauai. Likewise, it was determined that an island-associated (i.e., insular v. pelagic) population of short-finned pilot whales moves over an area spanning Kauai, Niihau, Kaula, and Oahu and associates with shelf habitat. In addition, tag data revealed site fidelity of rough-toothed dolphins to the Kauai and Niihau area, and that these animals' ranges substantially overlap with PMRF

(Baird et al. 2013c). In 2014, additional analysis of tags deployed in July 2013 revealed island-associated (i.e., insular v. pelagic) movement patterns in false killer whales belonging to the northwestern Hawaiian Islands population. Prior to this effort, false killer whales from this population had shown quite different patterns in spatial use, with broad-scale movements from Kauai/Nihoa to Gardner Pinnacles (Baird et al. 2013a, c). The individual tagged in July 2013 was from the same social group as at least two of the individuals tagged in July 2012, yet remained associated with the Kauai and Niihau area for the entire 21 days post-tagging.

Monitoring projects in 2014 continued efforts to further our understanding of exposure levels. In 2013, it was estimated that the RLs for beaked whales at PMRF varied from 52 to 137 dB re: 1 µPa (mean = 109 dB, standard deviation = 22 dB) while the animals were presumed to be at depth foraging during a naval training event. RLs were estimated assuming the animals were at/near the sea surface and averaged 40.1 dB higher than those estimated at foraging depth (Manzano-Roth et al. 2013). In 2014, RLs were estimated for several species during a ship-follow aerial survey during an SCC. Estimated RLs were calculated for sperm whales (three cases), humpback whales (two cases), and short-finned pilot whales (one case). Exposures were relatively high, with maximum estimates ranging from 158 to 174 dB re: 1µPa. These are higher than those reported by other comparable studies involving exposures to actual MFAS transmissions. Baird et al. (2014c) reported RLs of 130 to 144, 149 to 168, and 141 to 162 dB re: 1µPa for satellite-tagged cetaceans, including two rough-toothed dolphins, a bottlenose dolphin, and a short-finned pilot whale, respectively. The bottlenose dolphin showed no large-scale movements out of the area during sonar exposures despite these relatively high predicted RLs, and the short-finned pilot whale actually moved towards areas of higher exposures. Tyack et al. (2011) used existing U.S. Navy assets on the Atlantic Undersea Test and Evaluation Center (AUTEC) range in the Bahamas to track echolocating Blainville's beaked whales during U.S. Navy training involving AN/SQS-56 and AN/SQS-53C sonars, and estimated RLs ranging from 101 to 157 dB re: 1 µPa at distances of 2.2 to 28.9 km away from transmitting ships. Thus, circling U.S. Navy ships generally results in detecting animal exposures at higher levels than other methods of monitoring marine mammals.

Monitoring projects in 2014 also continued efforts to further understanding of marine mammal behavioral responses to MFAS. In 2013, no abnormal behavior was detected in Hawaiian monk seals during periods in which cell phone tag data overlapped with periods of MFAS (D'Amico 2013). However, there were statistically significant differences in dive rates of beaked whales after the initiation of a naval training event, in addition to observed diel occurrence patterns and spatial distributions of dives (Monzano-Roth et al. 2013). Acoustic analysis conducted in 2014 showed that minke whale boing call counts decreased in the presence of MFAS. There were fewer minke whale calls (and resultant localizations) during 'Phase B' (surface ship training with MFAS) training activities when compared with the periods prior to ship training. Likewise, beaked whale foraging dive rates decreased during periods of MFAS. There were more dives detected prior to MFAS than during and after sonar. Data indicate that beaked whale dives continued to occur at PMRF during MFAS transmission, although in reduced numbers.

Aerial shoreline surveys for stranded or distressed marine mammals along remote shorelines following MTEs began in 2009, and no strandings or near-strandings have been detected since these surveys began (Ampela et al. 2015). In 2013 and 2014, no stranded or near-stranded marine mammals or sea turtles were observed during over 3,200 km of aerial shoreline surveys in HRC following three U.S. Navy training events involving MFAS, consistent with previous results from post-training event shoreline surveys.

Monitoring projects in 2014 also involved in-depth analysis and reporting of data collected in previous monitoring years, but due to complexity or nature of the data, these efforts extended beyond the regulatory calendar. Four EARs were deployed from 2011 to 2013, and analysis was completed in January 2015. The results of the PAM analysis indicate the presence of Cuvier's beaked whales and Blainville's beaked whales. Fin, minke, and humpback whales were detected at Niihau and Kaula only in winter and spring. Analysis of EAR data using ROCCA revealed the presence of short-finned pilot whales, false killer whales, pantropical spotted dolphins, rough-toothed dolphins, bottlenose dolphins, and spinner/striped dolphins around Niihau and Kaula. There were no statistically significant differences in acoustic encounter rates for dolphins heard before, during, and after the use of MFAS.

A number of monitoring efforts in 2014 concentrated on comprehensive analysis of existing monitoring datasets. A novel, integrated approach used existing PMRF data and satellite-tag data (collected between 2011 and 2013) to estimate RLs for several species of marine mammals. A bottlenose dolphin showed no large-scale movements out of the area during sonar exposures despite relatively high RLs, and a short-finned pilot whale actually moved towards areas of higher exposures. Analysis of existing PMRF data revealed detections of Bryde's whale and tracks on PMRF, using burst-type calls attributed to the species. Over 400 Bryde's whale calls were tracked, and animals on the range exhibited a range of swim speeds. These encounters provide new information about Bryde's whale use of PMRF, and about Bryde's whale distribution and acoustic behavior in general. Another data analysis task resulted in the development of an automated method to track humpback whales at PMRF using song units attributable to individual animals. This method processes data five times faster than real-time with a predicted high level of spatial accuracy.

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3. Marine Species Monitoring in the SOCAL Range Complex

3.1 2014 SOCAL Monitoring Goals and Implementation

Table 3 summarizes current marine species monitoring projects conducted in 2014 in SOCAL in support of HSTT MMPA requirements (50 CFR Part 128). Intermediate scientific objectives are identified for each project at (http://www.navymarinespeciesmonitoring.us/ regions /pacific/current-projects/), as well as a brief summary of how/if each objective was met in 2014.

Table 3. 2014 SOCAL monitoring goals.

Project	Intermediate Scientific Objectives	Completed Requirements – Demonstrated Progress Made on the Following Project Objectives
PROJECT #1: UNDET Propagation Monitoring at SSTC. STATUS: COMPLETED	• Develop analytic methods to evaluate behavioral responses based on PAM techniques.	• Conduct near- and far-field measurements of UNDET sound propagation from EOD training events within the nearshore ocean waters of the SSTC. Data will be used to inform future modifications to the U.S. Navy's NAEMO. (See Executive Summary, Figures 6-9, Tables 2-4 in Soloway and Dahl 2015 **[1]**.)
PROJECT #2: Small-boat Surveys in NSDB and Nearshore Ocean Waters of SSTC. STATUS: COMPLETED	• Determine which species and populations of marine mammals and sea turtles are present in U.S. Navy range complexes. • Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities.	• Perform monthly small-vessel surveys in the ocean water areas in and near the SSTC and NSDB. A minimum of 12 surveys will be performed. Goal is to obtain nearshore marine mammal sighting data for density estimation. If insufficient sightings are obtained, information will be used qualitatively to contribute to the U.S. Navy's future marine mammal occurrence discussions. (See Sections 3.2 and 3.3, Figures 4-9, Table 2, Appendix A in Graham and Saunders 2015 **[2]**.)
PROJECT #3: Marine Species Observers Embarked on U.S. Navy Assets during Anti-submarine Warfare Training. STATUS: ONGOING	• Determine what populations of marine mammals are exposed to U.S. Navy training and testing activities.	• Primary goal is assessing LOE for mitigation (DDG) and assessing which species are present during training events.
PROJECT #4: Fin Whale Satellite Tagging in SOCAL. STATUS: ONGOING	• Determine which species and populations of marine mammals and sea turtles are present in U.S. Navy range complexes. • Determine which species and populations of marine mammals are exposed to Navy training and testing activities.	• Satellite tag tracking of fin whales along the U.S. West Coast including naval training areas in Southern California and Pacific Northwest as well as other areas of the Pacific. Goal is to compare long-term (up to a year) individual movement patterns and determine metrics of residence time in particular subareas. (See figures and summary text provided by Mate et al. 2015 **[4]**.)

Project	Intermediate Scientific Objectives	Completed Requirements – Demonstrated Progress Made on the Following Project Objectives
PROJECT #5: Blue Whale Satellite Tagging In SOCAL. STATUS: ONGOING	• Determine which species and populations of marine mammals and sea turtles are present in U.S. Navy range complexes. • Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities.	• Satellite-tag tracking of blue whales along the U.S. West Coast including naval training areas in SOCAL and NWTRC as well as other areas of the Pacific. Goal is to compare long-term (up to a year) individual movement patterns and determine metrics of residence time in particular subareas. (See figures and summary text provided by Mate et al. 2015 **[5]**.)
PROJECT #6: Blue Whale, Fin Whale, Humpback Whale, and Cuvier's Beaked Whale/Vocalization/ Echolocation and Impact Assessment From Anthropogenic Sounds. STATUS: ONGOING	• Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities. • Continue development of PAM techniques and tools for detecting, classifying, and tracing marine mammals.	• Comparison of two (and possibly three) long-term, bottom-mounted HARPs over a year using new nearshore PAM off La Jolla, and established offshore PAM. Specific goal would to analyzed vocalization or echolocation rates for key species in terms of changes or lack of change in presence of anthropogenic sounds. Secondary goal would be to document occurrence of these species over each year. (See figures and summary text provided by Debich et al. 2015a,b **[6a, 6b]**.) • Develop a method to provide better metrics for quantifying MFAS occurrence (See summary provided by Wiggins et al. 2015 **[6c].**
PROJECT #7: Fin Whale and Cuvier's Beaked Whale Vocalization/Echolocation and Impact Assessment From Anthropogenic Sounds at U.S. Navy's SOAR. STATUS: ONGOING	• Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities. • Continue development of PAM techniques and tools for detecting, classifying, and tracking marine mammals.	• Continued Cuvier's beaked whale and fin whale population assessments within SOAR and Southern California. (See text from Falcone and Schorr 2014 **[7a].**) • Continued development of U.S. Navy's M3R system that utilizes an array of existing bottom-mounted hydrophones in San Nicolas Basin. Goal would be improvements and validation of M3R for Cuvier's beaked whale and fin whale detection and localization. Information from concurrent U.S. Navy training on SOAR can be used to assess the impact training events may or may not have on species presence or vocalizations. (See Section - 'Mid-term reaction (days to weeks) to MFA sonar,' Figures 7-8 in Moretti 2015 **[7b]**.)
PROJECT #8: Marine Mammal Visual Sightings during CalCOFI cruises. STATUS: ONGOING	• Determine which species and populations of marine mammals and sea turtles are present in U.S. Navy range complexes. • Determine which species and populations of marine mammals are exposed to U.S. Navy training and testing activities.	• Ten-year dataset of marine mammal sightings within Southern California based on vessel surveys performed four times per year. Effort continuing through 2015. • Sufficient data for generation of species-specific seasonal densities and abundance trends at finer spatial and temporal scales than standard NMFS U.S. West Coast surveys, which are performed every 3 to 6 years. U.S. Navy is funding data integration to update NMFS' spatial habitat models. (See Campbell et al. 2015 **[8a]**, Douglas et al. 2014 **[8b]**.)

Key: CalCOFI = California Cooperative Oceanic Fisheries Investigations; DDG = guided missile destroyer; EOD = Explosive Ordnance Disposal; HARP = High-frequency Acoustic Recording Package; LOE = lookout effectiveness; M3R = marine mammal monitoring on Navy ranges; MFA = mid-frequency active; MFA = mid-frequency active; MMO = marine mammal observer; NAEMO = Navy Acoustic Effects Model; NMFS = National Marine Fisheries Service; NSDB = north San Diego Bay; NWTRC = Northwest Training Range Complex; PAM = passive acoustic monitoring; SOAR = Southern California Offshore Anti-submarine Warfare Range; SOCAL = Southern California Range Complex; SSTC = Silver Strand Training Complex; UNDET = underwater detonation; U.S. = United States.

3.1.1 Timeline of SOCAL Monitoring Efforts

The SOCAL Range Complex is depicted in **Figure 13**. All U.S. Pacific Fleet-funded monitoring and research tasks implemented in SOCAL and SSTC from 01 January 2014 through 31 December 2014 are illustrated in **Figure 14**. Details of individual tasks, organized by project, are in the sections following.

Project 1: Underwater Detonation Propagation Modeling at the Silver Strand Training Complex

[1] Noise Source Level and Propagation Measurement of Underwater Detonation Training at the Silver Strand Training Complex, Naval Base Coronado, Coronado, CA [Soloway and Dahl 2015]

Acoustic and visual monitoring was conducted in conjunction with two UNDET training events in the SSTC on May 2014. Near and far-field measurements were performed using two vessels, a hydrophone vertical line array, a single-hydrophone array, and loggerhead autonomous hydrophone recording devices. Underwater sound measurements of these events were conducted with a focus on peak pressures and SELs. These metrics were compared with empirical models to improve the modeling of such sound for assessing potential impacts on marine life. Environmental data were collected in conjunction with acoustic measurements, including sound speed v. depth for thermocline characterization, and sea surface directional wave measurements. Visual monitoring for marine mammals and sea turtles was conducted before, during, and after all four UNDET events (see **Project 3**).

Project 2: Small-boat Surveys in North San Diego Bay and Nearshore Ocean Waters of the Silver Strand Training Complex

[2] Occurrence, Distribution, and Population Estimates of Marine Mammals near Silver Strand Training Complex and San Diego Bay [Graham and Saunders 2015]

Visual surveys were conducted using a small vessel between October 2013 and September 2014 (Graham and Saunders 2015). Surveys followed standard line-transect methods to gather baseline data on the occurrence, distribution, and abundance of marine mammals during the warm- and cool-water seasons, near SSTC and in San Diego Bay.

Project 3: Marine Species Observers Embarked on U.S. Navy Assets during Anti-submarine Warfare Training

During the course of this reporting period from December 2013 through December 2014, no MMO embarks were conducted in SOCAL. Significant challenges were encountered in the arrangement of suitable ship opportunities in which an MMO team could be embarked. These included sequestration budget impacts leading to reduction in sea time, commitment of MMOs to embarks in other geographic areas (e.g., Hawaii), long duration of SOCAL at-sea training periods for available ships (i.e., DDGs, CGs) beyond what an MMO team can typically support (generally < 10 days), and the highly unpredictable, dynamic, and rapidly shifting schedule of unit level training. To resolve these issues and plan for additional SOCAL embarks in 2015, U.S. Pacific Fleet has reinitiated dialog with senior U.S. Navy commands to enhance the visibility of the MMO embark need this calendar year. The current planning goal is to obtain two SOCAL MMO embarks prior to the end of December 2015. Optionally, U.S. Pacific Fleet will also explore the availability of additional assets striving for a maximum of up to four MMO embarks.

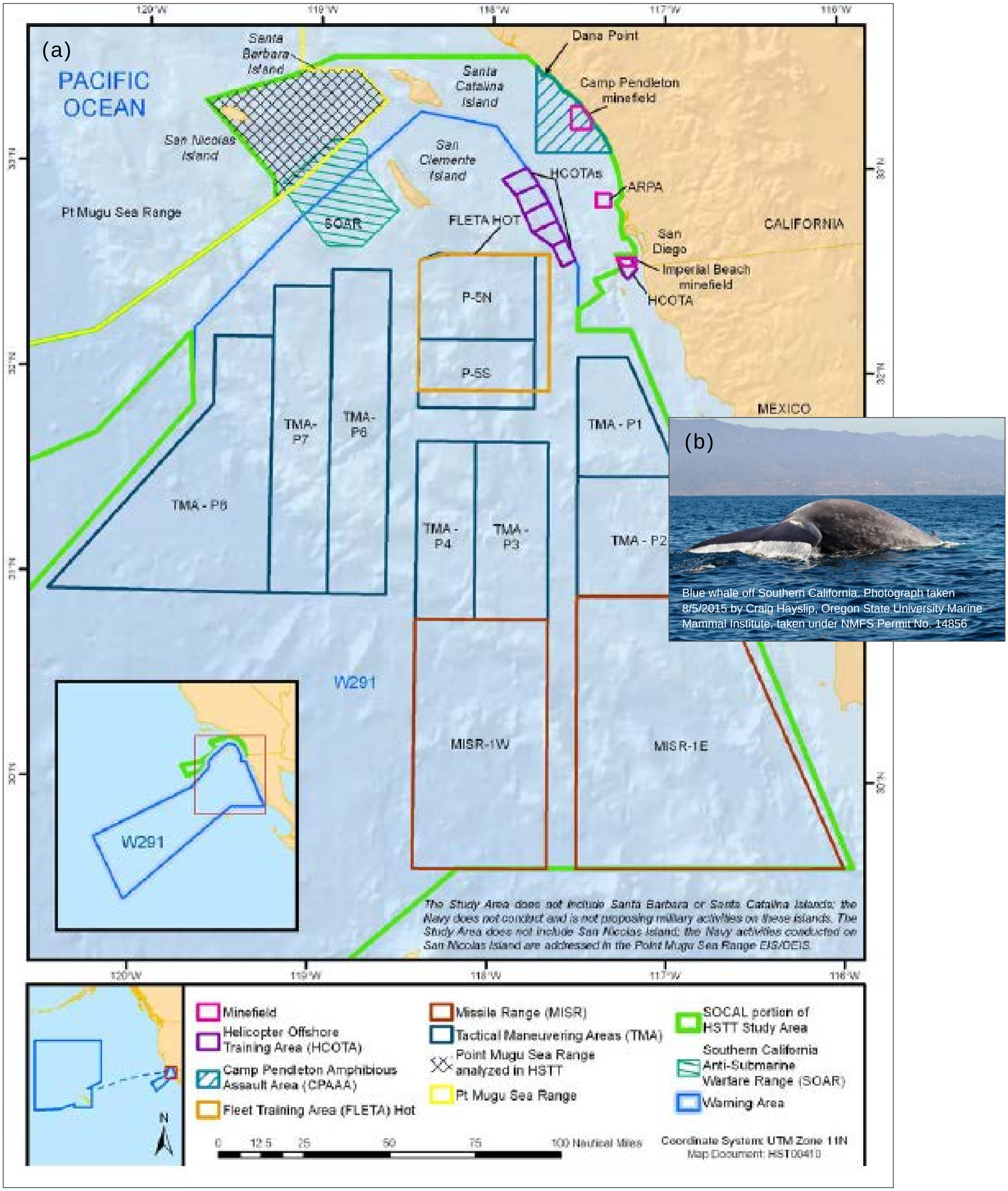

Figure 13. The SOCAL Range Complex (a), and blue whale off Southern California (b). Photo courtesy of Oregon State University, Marine Mammal Institute.

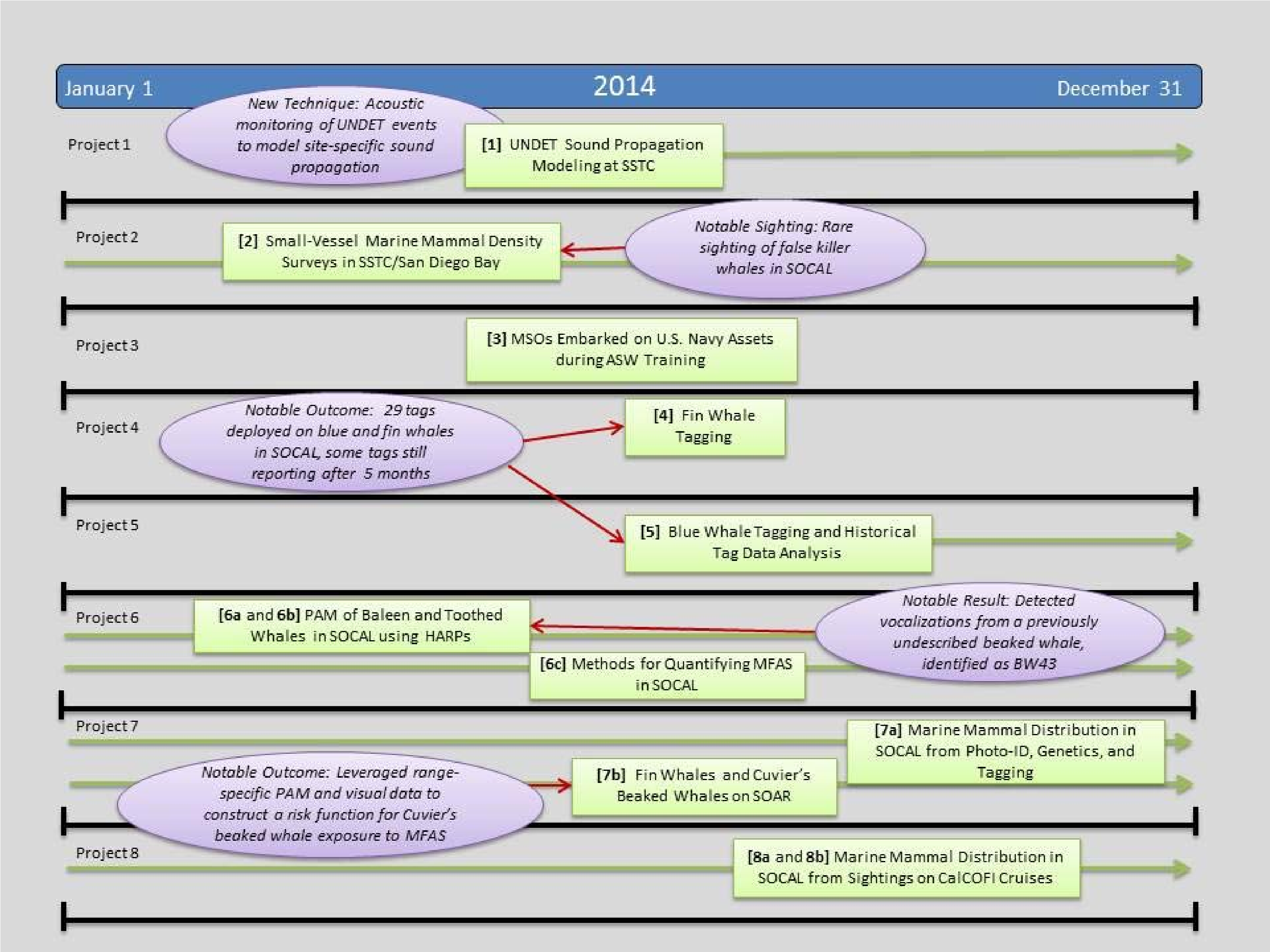

Figure 14. Timeline of 2014 monitoring projects in SOCAL.

To resolve this and obtain additional SOCAL embarks for 2015, U.S. Pacific Fleet has reinitiated dialog with senior Navy commands to enhance the visibility of the MMO embark need this calendar year. Current planning goal is to obtain two (2) SOCAL MMO embarks prior to the end of December 2015. Optionally, U.S. Pacific Fleet will also explore the availability of additional assets during this time, striving for a maximum of up to four (4) MMO embarks

Projects 4 and 5: Blue and Fin Whale Tagging in SOCAL

[4] and [5] Preliminary Summary: Baleen (Blue & Fin) Whale Tagging in Southern California in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas (SOCAL, NWTRC, GOA) [Mate et al. 2015]

Between 25 July and 12 September 2014, blue and fin whales were tagged off Southern California. The purpose of this effort was to tag species that may migrate through multiple U.S. Navy training ranges or training areas such as SOCAL, the Northwest Training Range Complex, and the Gulf of Alaska Temporary Maritime Activities Area. Tag data were analyzed to compare long-term (up to a year) individual movement patterns and determine metrics of residence time in particular subareas. Tag data also were analyzed for evidence of individual variation in movement patterns and dive habits in relation to prey, water depth, and weather patterns. The 2014 advanced dive behavior (ADB) tag data are currently being analyzed. In addition, an analysis is underway of historical data from 173 location-only tags deployed on blue whales from 1993 through 2008. Output from switching state-space models applied to these tracks will be used to determine areas of migration and foraging along the U.S. West Coast relative to U.S. Navy ranges, and home-range analysis using fixed kernel density approaches will be used to determine which areas were most important to tagged whales, and the degree of overlap with U.S. Navy ranges, during this period.

Project 6: Passive Acoustic Monitoring—Blue Whale, Fin Whale, Humpback Whale, and Cuvier's Beaked Whale/Vocalization/Echolocation and Impact Assessment from Anthropogenic Sounds

[6a] Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training Area Dec 2012 – Jan 2014 [Debich et al. 2015a]

PAM was conducted in SOCAL from December 2012 to January 2014 to detect marine mammal and anthropogenic sounds. High-frequency Acoustic Recording Packages (HARPs) recorded sounds between 10 Hz and 100 kHz at three locations (**Figure 15**): near Santa Barbara Island, west of San Clemente Island (SCI), and southwest of SCI. Data analysis involved manual scanning of long-term spectral averages and spectrograms, as well as detection using automated computer algorithms when possible. Three frequency bands were analyzed for marine mammal vocalizations and anthropogenic sounds.

[6b] Passive Acoustic Monitoring for Marine Mammals in the SOCAL Range Complex January – July 2014 [Debich et al. 2015b]

PAM was conducted in SOCAL from January to July 2014 to detect marine mammal and anthropogenic sounds. HARPs recorded sounds between 10 Hz and 100 kHz at three locations (**Figure 15**): near Santa Barbara Island, west of SCI, and southwest of SCI. Data analysis involved manual scanning of long-term spectral averages and spectrograms, as well as detection using automated computer algorithms when possible.

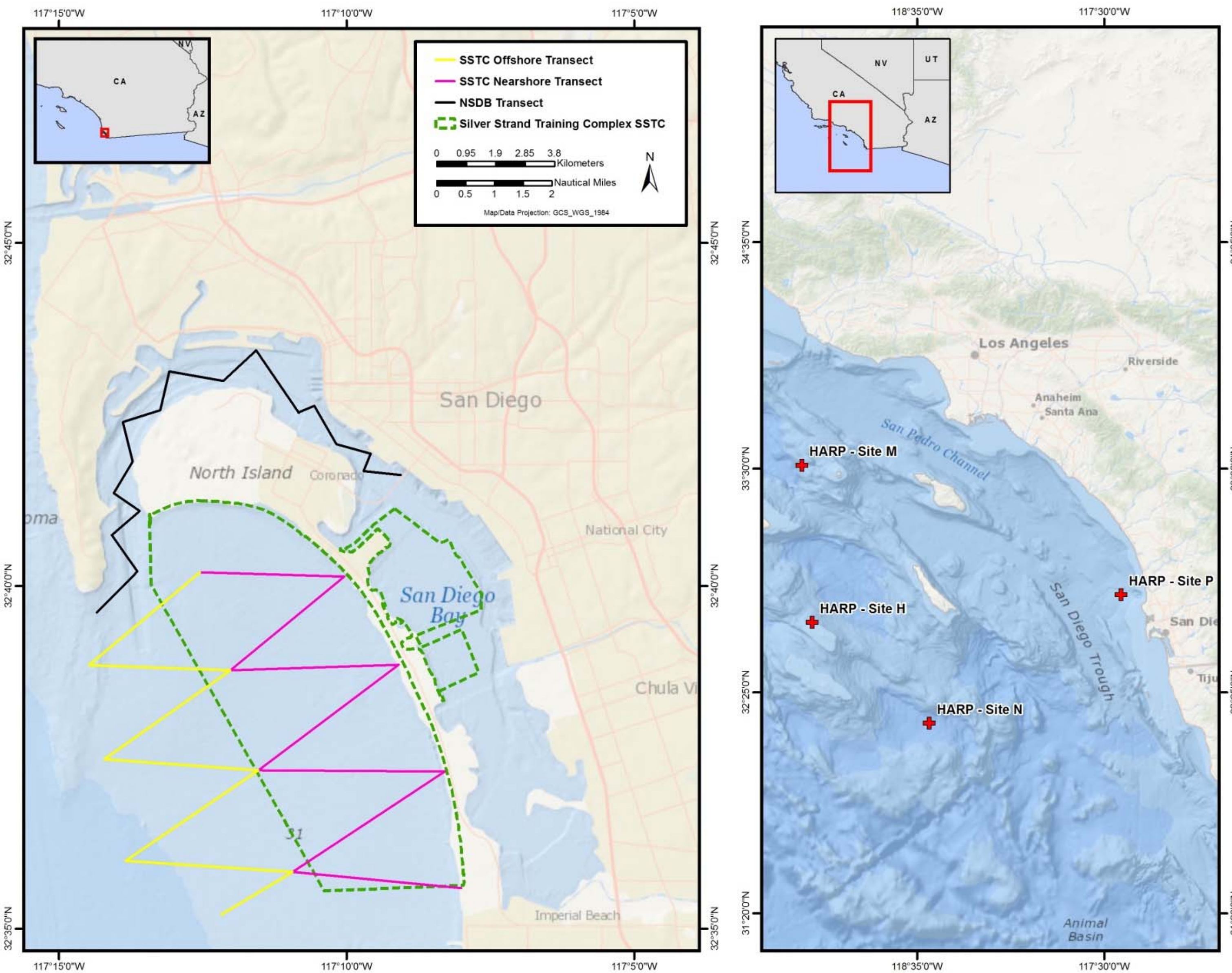

Figure 15. Survey effort from small-vessel visual surveys conducted in SOCAL in 2014 (see project [2] (left); Locations of four HARPS deployed off Southern California (see projects [6a, 6b, 6c]).

Three frequency bands were analyzed for marine mammal vocalizations and anthropogenic sounds.

[6c] Methods for Quantifying Mid-frequency Active Sonar in the SOCAL Range Complex [Wiggins 2015]

A new method was developed to provide better metrics for quantifying MFAS occurrence and levels, and was applied to PAM data collected in SOCAL from March 2009 through January 2014 (see projects **[6a]** and **[6b]**). Cumulative SEL (CSEL) for each wave train event was calculated as the sum of the packet SELs. Further enhancements to this new approach for quantifying MFAS activity will be developed in conjunction with continuing marine mammal impact studies. In addition, given the novel development of this technique, cross-comparisons with related efforts funded by the Office of Naval Research and Living Marine Resources programs will be made.

Project 7: Passive Acoustic Monitoring – Fin Whale and Cuvier's Beaked Whale Vocalization/Echolocation and Impact Assessment from Anthropogenic Sounds at Navy's Southern California Offshore Antisubmarine Warfare Range

[7a] Distribution and demographics of marine mammals in SOCAL through photoidentification, genetics, and satellite telemetry [Falcone and Schorr 2014]

Falcone and Schorr (2014) summarized data collected during small-vessel surveys for cetaceans in Southern California, with a focus on SOAR, from June 2010 through January 2014. This Navy-funded effort was managed under the Chief of Naval Operations Environmental Readiness Division (OPNAV N4) prior to transitioning to the U.S. Navy’s Living Marine Resources program. In addition, these field efforts were performed in coordination with and in support of project **[7b]** (Moretti 2015). Detailed annual progress reports were prepared after each survey year through 2013 and are available online through the Naval Postgraduate School. This final report emphasizes analyses that combine data across study years, particularly with respect to two focal species: Cuvier's beaked and fin whales.

[7b] Marine Mammal Monitoring on Navy Ranges 2014 Summary Report February, 2015 [Moretti 2015]

The 172 bottom-mounted SOAR hydrophones in San Nicolas Basin (West of SCI) are currently being leveraged to develop tools to identify and track marine mammals on the range, with initial focus on Cuvier’s beaked whales and ESA-listed fin whales. An integrated approach has been developed which incorporates acoustic, photo-identification, and telemetry datasets, allowing researchers to document temporal and spatial trends in species assemblages, improve our understanding of population size and structure, measure habitat usage, refine mark-recapture estimates based on photo-identification data, and measure foraging rates and reactivity to naval training and testing activities. Project objectives include estimating individual and population-level responses to MFAS and impacts to Cuvier’s beaked whales and fin whales; development of prototype passive acoustic tools to estimate densities of Cuvier’s beaked whales; and documenting the spatial and temporal reaction of both species to MFAS. These data will be combined with ship track data and sonar data recorded by range hydrophones to estimate RLs at the location of detected groups of Cuvier’s beaked whales using a species-specific risk function.

Project 8: Marine Mammal Visual Sightings during Seasonal California Cooperative Oceanic Fisheries Investigations (CalCOFI)

[8a] Inter-annual and seasonal trends in cetacean distribution, density and abundance off Southern California [Campbell et al. 2015]

[8b] Seasonal distribution and abundance of cetaceans off Southern California estimated from CalCOFI cruise data from 2004 to 2008 [Douglas et al. 2014]

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises, a joint agency field effort, have been conducted in Southern California for over 61 years. More information on the overall history of the CalCOFI program is available at: http://www.calcofi.net/.

Beginning in 2004, the Chief of Naval Operations Environmental Readiness Division (OPNAV N45) funded the collection of marine mammal visual and passive acoustic data during regularly scheduled CalCOFI cruises, which occur four times per year. U.S. Pacific Fleet specifically funded CalCOFI marine mammal data collection during 2013, 2014, and continuing into 2015. The CalCOFI marine mammal efforts represent one of the few cool-water (i.e., winter, spring) vessel surveys in the region, with the exception of the U.S. Pacific Fleet's ongoing aerial surveys that have also sampled during cool-water periods. Each CalCOFI cruise consists of sampling the same survey tracklines including coverage offshore (> 100 nm). Spatial and temporal distribution patterns, density, and abundance of cetaceans in the Southern California were assessed using visual and acoustic methods. The CalCOFI data represent the only continuous, seasonal marine mammal information available for Southern California. Campbell et al. (2015) and Douglas et al. (2014) summarize peer-reviewed published results from Navy-funded CalCOFI efforts. In addition to publication, CalCOFI data is also being used in 2014-2015 U.S. Pacific Fleet-funded efforts to improve NMFS' West Coast marine mammal spatial habitat models with inclusion of additional seasonal and annual sighting information.

3.2 Results: Progress Made on 2014 SOCAL Monitoring Projects

Results and key conclusions from the seven SOCAL monitoring projects are summarized below. **Figure 15** shows sightings, survey effort, and PAM device locations from field projects executed in 2014. Notable outcomes for each project are listed in **Table 4**.

Table 4. Quick-look summary of progress made in 2014 on SOCAL monitoring questions.

Monitoring Questions	Progress Made in 2014 and Notable Outcomes
What is the underwater energy and sound propagation from underwater detonations at the SSTC?	Acoustic monitoring was conducted in conjunction with UNDETs at SSTC, and site-specific sound propagation characteristics were modeled for the area, taking environmental conditions into account **[1].**
What is the occurrence and density of marine mammals within the coastal waters of the SSTC and north San Diego Bay?	Abundance and density estimates were calculated for California sea lions and dolphins (common and bottlenose dolphins, pooled) in SSTC and NSDB. In March 2014, a single sighting of false killer whales was recorded. This species is normally found in tropical waters and rarely observed in SOCAL. The false killer whale sighting was closer to the San Diego Bay shipping channel and well outside of the SSTC boat lanes and areas used for UNDET training **[2].**
What is the effectiveness of Navy lookouts on Navy surface ships for mitigation, and what species are sighted during sonar training events?	Work in progress. Current planning goal is to obtain two SOCAL MMO embarks prior to the end of December 2015. Optionally, U.S. Pacific Fleet will also explore the availability of additional assets during this time, striving for up to four MMO embarks.
What are the occurrence, movement patterns, and residency patterns of blue and fin whales within U.S West Coast at-sea ranges as compared to the rest of their distribution throughout the Pacific Ocean?	A combination of location-only (SPOT5) and ADB tags was deployed on 5 fin whales off the coast of Southern California. One of the SPOT5 tags deployed in August 2014 was still reporting as of December 2014. Data from ADB tags deployed on fin whales are still being analyzed **[4].**
What are the occurrence, movement patterns, and residency patterns of blue and fin whales within U.S West Coast at-sea ranges as compared to the rest of their distribution throughout the Pacific Ocean?	A combination of location-only and ADB tags was deployed on 24 blue whales off the coast of Southern California. Two of the tags were still sending data after 150 days, and as of February 2015, these individuals were 8 to 10 degrees north of the equator. Preliminary data from ADB tags revealed strong and consistent diel feeding patterns in blue whales (deep daytime dives and shallow night dives) **[5].**
What are the impacts of anthropogenic sound on blue whale, fin whale, humpback whale, and Cuvier's beaked whale vocalization and echolocation?	Acoustic signals were detected from fin whales, humpback whales, sperm whales, Baird's beaked whales, Cuvier's beaked whales, and an unknown beaked whale species identified as BW43. A variety of anthropogenic sounds was detected, including broadband ship noise, echosounders, explosions, underwater communications, sonar, and a previously undescribed sound near 180 Hz **[6a, 6b].** Using data collected during projects **[6a]** and **[6b],** as well as similar data collected in previous years, a new metric to estimate sonar occurrence was proposed, which uses a measure of CSEL. This method provides a measure of the total energy emitted during an event, a useful metric for marine mammal impact studies. Future work will refine this methodology, compare it to other Navy- funded methodologies, and apply it to previous and ongoing passive acoustic data collection efforts **[6c].**

Monitoring Questions	Progress Made in 2014 and Notable Outcomes
What are the impacts of anthropogenic sound on fin whale and Cuvier's beaked whale vocalization and echolocation within the Southern California Offshore Antisubmarine Warfare Range (SOAR)?	A multi-year analysis of Cuvier's beaked and fin whale occurrence in SOCAL was completed. Cuvier's beaked whales and fin whales were persistently present in an area of repeated sonar use, suggesting that these whales may be part of a smaller regional subpopulation rather than transient members of a large and dispersed U.S. West Coast population. Many fin whales also appear to preferentially remain within the Southern California year-round, with increased use of nearshore waters in fall and winter. Sufficient sighting and photographic ID data for Cuvier's beaked whales have been collected to begin estimation of key population vital rates (e.g. calving rates). Data products for transitioning M3R from LMR funding to Fleet monitoring funding have been identified and will be forthcoming in future years **[7a, 7b].**
What are the spatial and temporal patterns of marine mammal occurrence in SOCAL?	Cumulative results from 10 years of seasonal marine mammal sightings have been published. These include some of the first population trend analyses based on recent sightings data **[8a,8b]**

Key: ADB = Advanced Dive Behavior; CSEL = cumulative SEL; DDG = guided missile destroyer; Hz = Hertz; LFAS = low-frequency active sonar; M3R = marine mammal monitoring on Navy ranges; MFAS = mid-frequency active sonar; MMO = Marine Mammal Observer; NSDB = north San Diego Bay; PAM = passive acoustic monitoring; SOCAL = Southern California Range Complex; SOAR = Southern California Anti-submarine Warfare Range; SPOT5 = Smart Position and Temperature; SSTC = Silver Strand Training Complex; UNDET = underwater detonation; U.S. = United States.

3.2.1 Project 1: Underwater Detonation Propagation Monitoring at the Silver Strand Training Complex

Monitoring Question: What is the underwater energy and sound propagation from underwater detonations at the Silver Strand Training Complex (SSTC)?

[1] Soloway and Dahl 2015

Sound measurements were performed from near- and far-field monitoring vessels (**Figures 16 and 17**) during four underwater detonations at SSTC in May 2014. Peak pressures ranged from 209 to 222 dB re 1 μPa (recorded at 1,651 and 358 m, respectively). The SEL ranged from 184 to 191 dB re 1 μPa^{2}s (recorded at 1,651 and 358 m, respectively). Peak pressure increased with depth, varying by up to 4 dB for the approximately 6-m depth span of the vertical line array. This depth dependence was likely due in part to the sound velocity gradient associated with the thermocline. The water column was characterized by a thermocline resulting in a sound speed that varied from approximately 1,510 meters per second (m/s) near the sea surface to 1,492 m/s near the seabed. Sea surface directional wave measurements were also collected (RMS wave heights between 0.16 and 0.19 m) and will be employed for future modeling efforts.

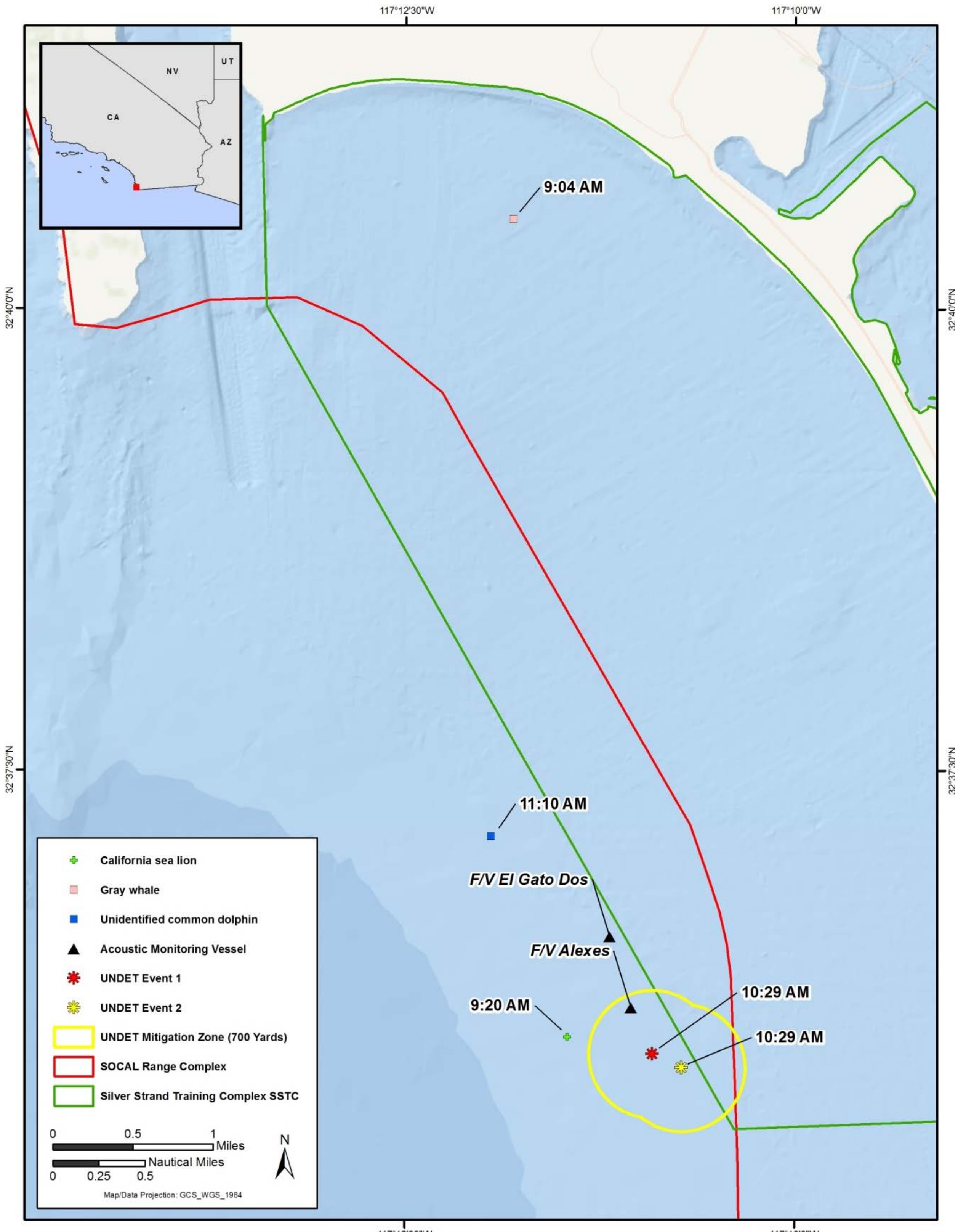

Figure 16. Marine mammal observations, monitoring vessel positions, and detonation locations on 13 May 2014 (Soloway and Dahl 2015 [1] and [3]).

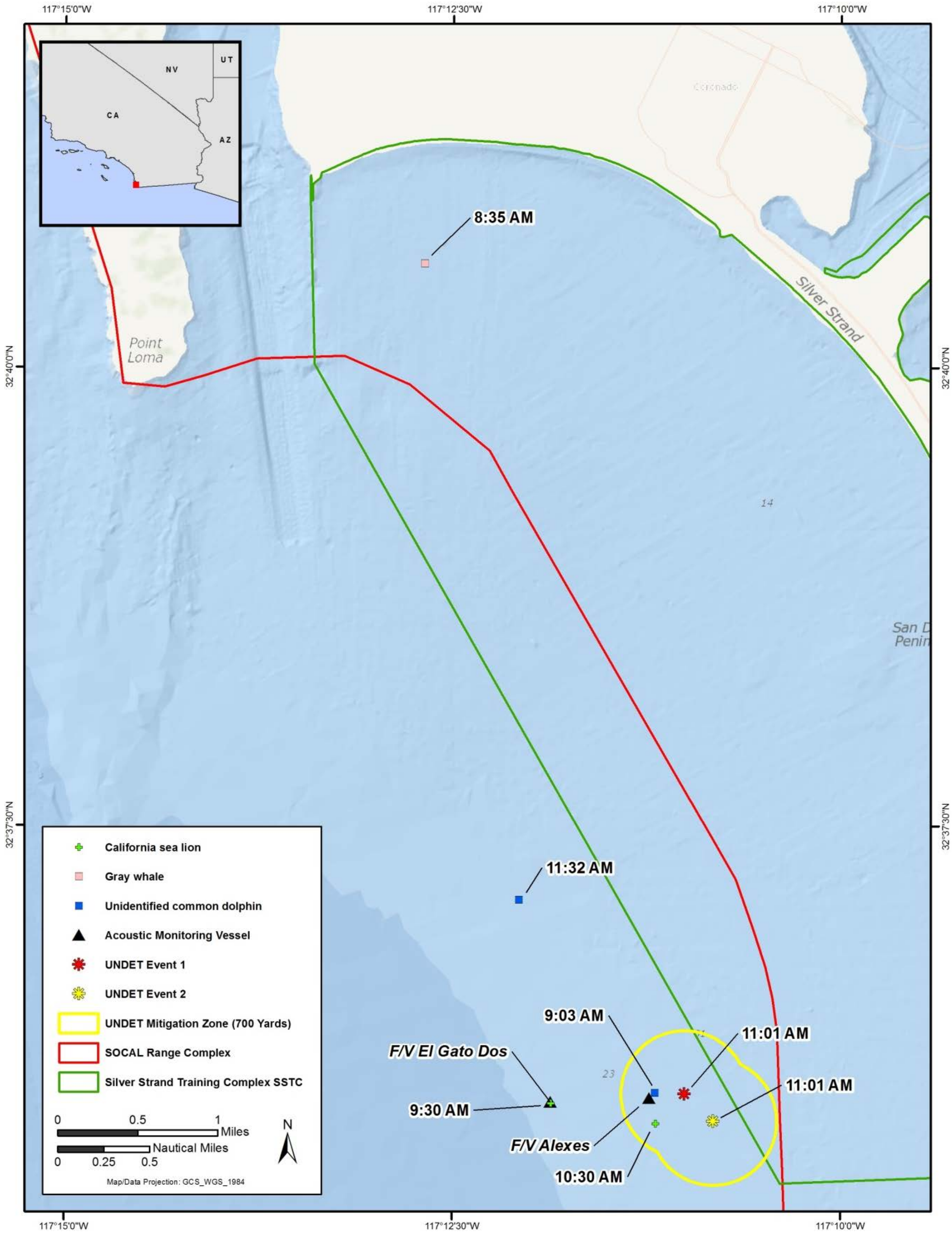

Figure 17. Marine mammal observations, monitoring vessel positions, and detonation locations on 14 May 2014 (Soloway and Dahl 2015 [1] and [3]).

3.2.2 Project 2: Small-Boat Surveys in Northern San Diego Bay and Nearshore Ocean Waters of the Silver Strand Training Complex

Monitoring Question: What is the occurrence and density of marine mammals within the coastal waters of the Silver Strand Training Complex and north San Diego Bay?

[2] Graham and Saunders 2015

A Distance-based visual line-transect survey was designed to gather baseline data on the occurrence, distribution, and population estimations of marine mammals near Silver Strand Training Complex (SSTC) and north San Diego Bay (NSDB). The nearshore SSTC survey zone encompassed a 77.6 square kilometer (km^2) area that extended from shore out to 8.98 km, which included 14 Navy boat lanes (utilized as training areas). The heavily utilized northern portion of San Diego Bay was also surveyed within a 17.5 km^2 area that covered the north and north central ecoregions of San Diego Bay.

Between October 2013 and September 2014, monthly small-vessel surveys were conducted in SSTC and north San Diego Bay (NSDB). During the course of these efforts, 280 observations were made in the survey areas (**Figure 18**). Six marine mammal species were sighted, with the predominant species being California sea lions (*Zalophus californianus* [SSTC, n=132] and NSDB, n=109). Higher abundances of California sea lions were found in NSDB than SSTC, which is likely due to the highly urbanized environment of NSDB, since this area features numerous haul-out platforms regularly used by sea lions for resting areas.

Odontocete observations (n=26) were largely comprised of *Tursiops truncatus* and *Delphinus* spp. There were six gray whales (*Eschrichtius robustus*) sightings in the nearshore shallow waters of SSTC during January, February, and April-June. Additionally, a small pod of false killer whales (n=four individuals) was sighted on 20 March 2014. This species normally prefers warmer tropical waters than those of Southern California. Spring through fall of 2014 saw higher than normal sea surface temperatures throughout the U.S. West Coast.

Conventional distance sampling analyses indicated that there was a greater density estimation of in-water SSTC California sea lions during the cool seasonal period (n=51, 1.63 individuals per km^2) when compared to the warm period (n=59, 1.26 individuals per km^2). In examining density differences between nearshore (3.45 individuals/km^2) and pooled offshore (5.35 individuals/km^2), there was a greater density found within the offshore region. When comparing differences between in-water nearshore (3.45 individuals/km^2) and in-water offshore (2.17 individuals/km^2), the greater density in the nearshore may be attributed to the rich foraging grounds found in the kelp beds. In-water NSDB California sea lion density estimates were pooled for warm and cool periods (n=19, 13.0 individuals per km^2). Within SSTC, dolphin species observations were pooled for density estimations (4.55 individuals per km^2).

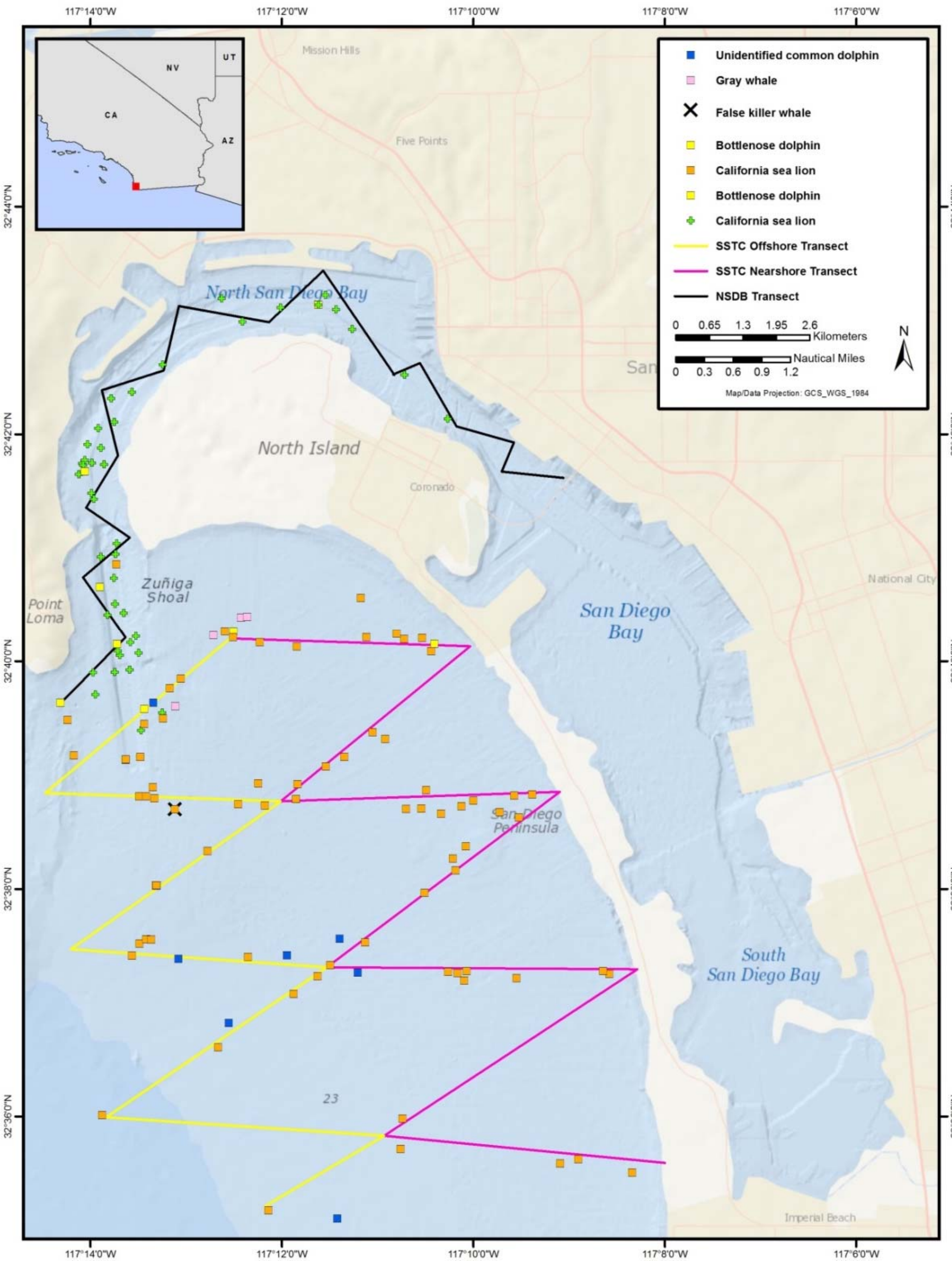

Figure 18. Marine mammal sightings recorded during small-vessel line-transect surveys in the SSTC and NSDB in 2014 (Graham and Saunders 2015 [2]). Effort lines indicate planned survey transects and not actual vessel tracklines.

3.2.3 Project 3: Marine Species Observers Embarked on U.S. Navy Assets during Anti-submarine Warfare Training

Monitoring Question: What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighting during sonar training events?

During the course of this reporting period from December 2013 through December 2014, no MMO embarks were conducted in SOCAL. Significant challenges were encountered in the arrangement of suitable ship opportunities in which an MMO team could be embarked. These included sequestration budget impacts leading to reduction in sea time, commitment of MMOs to embarks in other geographic areas (e.g., Hawaii), long duration of SOCAL at-sea training periods for available ships (i.e., DDGs, CGs) beyond what an MMO team can typically support (generally < 10 days), and the highly unpredictable, dynamic, and rapidly shifting schedule of unit level training.

To resolve these issues and plan for additional SOCAL embarks in 2015, U.S. Pacific Fleet has reinitiated dialog with senior U.S. Navy commands to enhance the visibility of the MMO embark need this calendar year. The current planning goal is to obtain two SOCAL MMO embarks prior to the end of December 2015. Optionally, U.S. Pacific Fleet will also explore the availability of additional assets striving for a maximum of up to four MMO embarks.

3.2.4 Projects 4 and 5: Fin and Blue Whale Satellite Tagging in Southern California

Monitoring Question: What are the occurrence, movement patterns, and residency patterns of blue and fin whales within U.S West Coast at-sea ranges as compared to the rest of these whales distribution throughout the Pacific Ocean?

[4] and [5] Mate et al. 2015

Satellite tags were deployed on blue and fin whales as part of the same field and reporting effort; therefore, results from both projects are combined here. Argos-monitored satellite tags were attached to 24 blue whales (20 SPOT-5, 4 ADB) and 6 fin whales (3 SPOT-5, 3 ADB) during August and September 2014 (Mate et al. 2015). One blue whale tag between 8 and 10 degrees of the equator in the Eastern Tropical Pacific was still sending data after approximately 5–6 months as of 9 March 2015. Average tag duration for the SPOT-5 location only tags was 58.8 days for blue whales and 94.8 days for fin whales. Total cumulative distance covered by all blue whale SPOT-5 location tags was 71,522 km (38,619 nautical miles [nmi]). Total cumulative distance covered by all fin whale SPOT-5 location tags was 15,721 km (8,489 nmi). Tag tracks for SPOT-5 locations by species are presented in **Figures 19 and 20**.

The following is an extract from Mate et al. (2015), and summarizes data collected through January 2015:

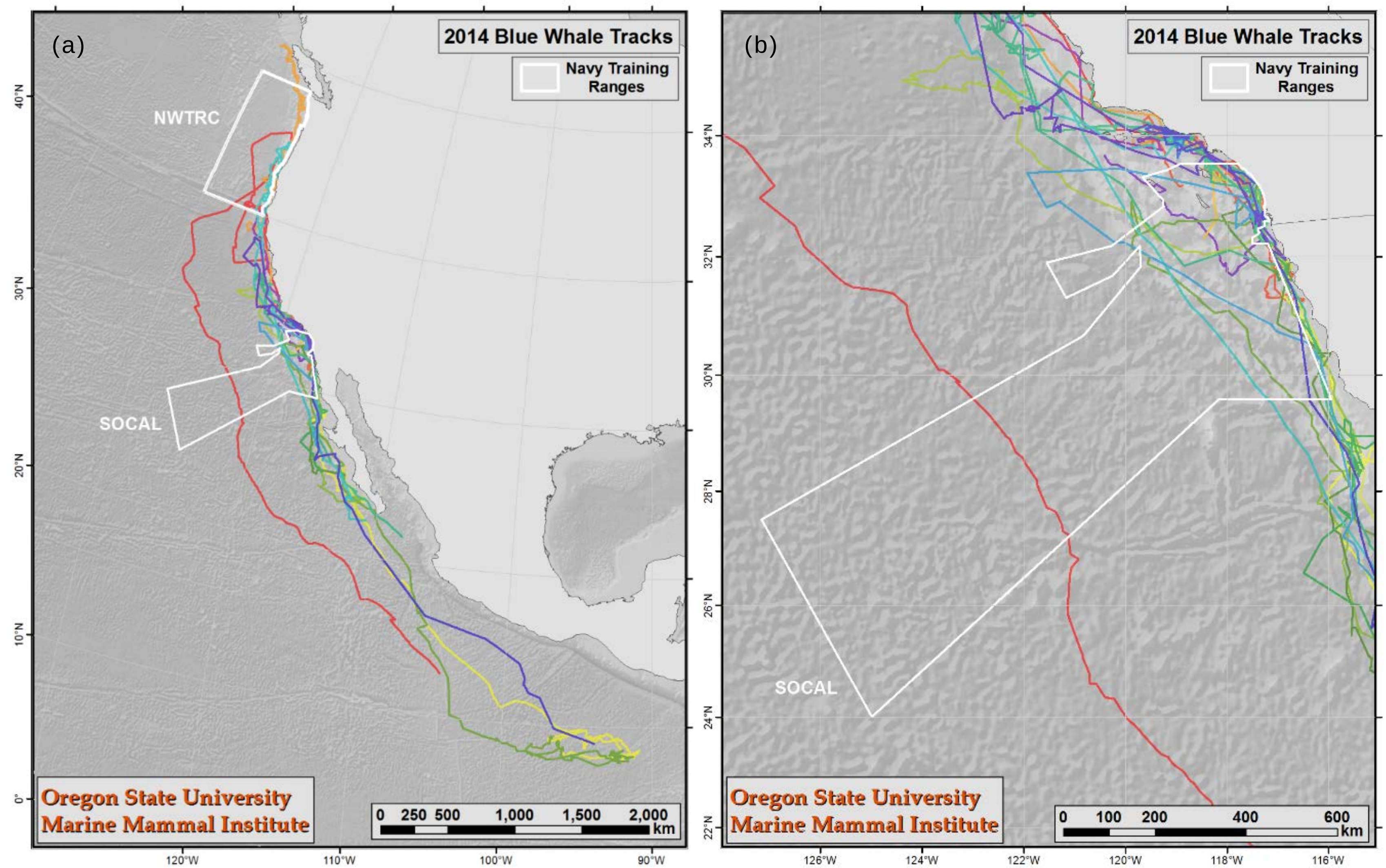

Figure 19. Satellite-monitored radio tracks for blue whales tagged off Southern California, 2014. Panel (a) shows Argos locations from SPOT-5 (*n*=18) and ADB (*n*=4) tags along the U.S. West Coast. Panel (b) shows Argos locations from SPOT-5 (*n*=15) and ADB (*n*=3) tags in SOCAL. The date range shown in both panels is from 03 August 2014 through 31 January 2015. (Source: Mate et al. 2015 [4], used with permission.)

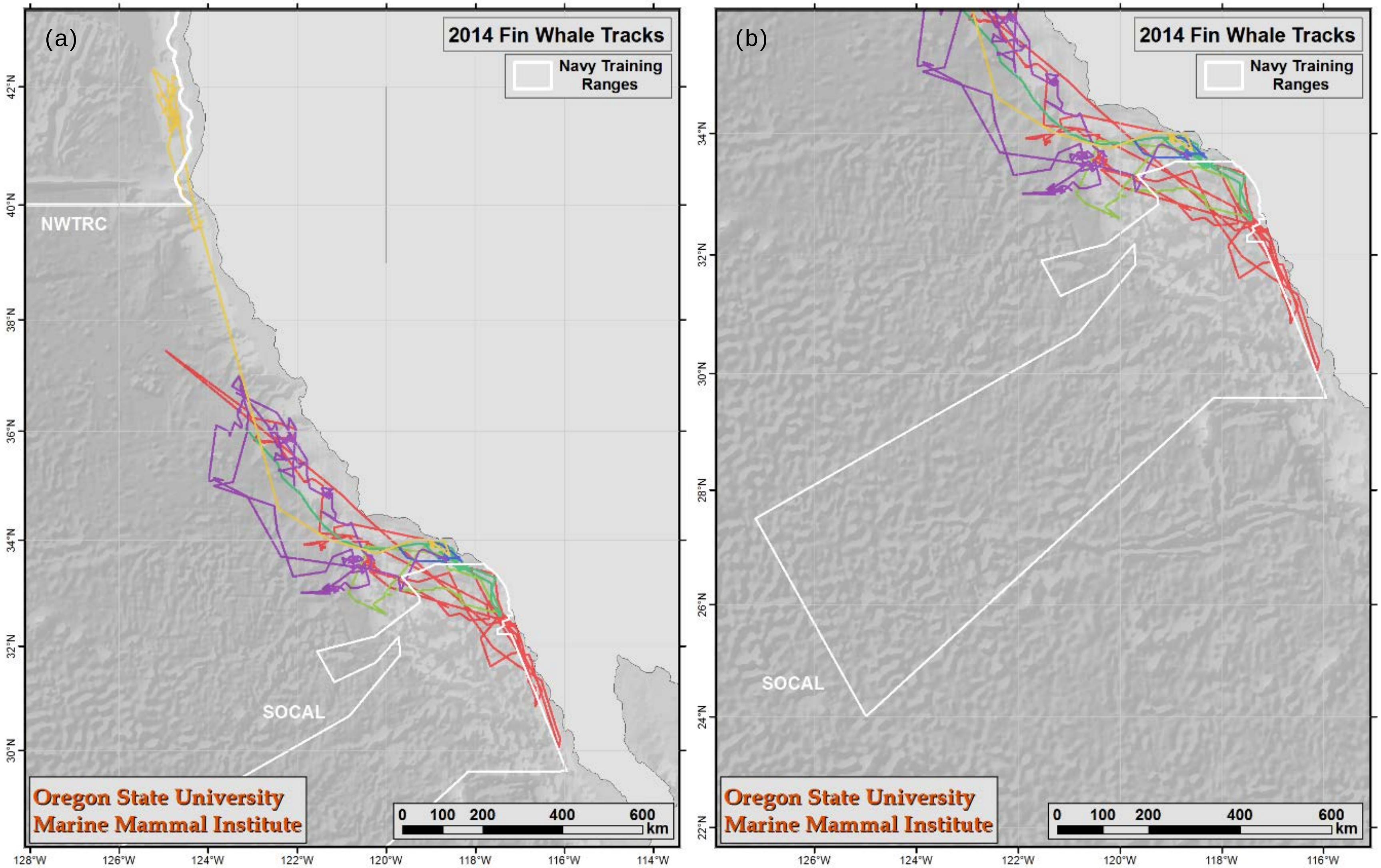

Figure 20. Satellite-monitored radio tracks for fin whales tagged off Southern California, 2014. Panel (a) shows Argos locations from SPOT-5 (*n*=3) and ADB (*n*=3) tags along the U.S. West Coast. Panel (b) shows Argos locations from SPOT-5 (*n*=1) and ADB (*n*=3) tags in SOCAL. The date range shown in both panels is from 03 August through 24 December 2014. (Source: Mate et al. 2015 [5], used with permission.)

3.2.4.1 LOCATION-ONLY TAGS

Blue Whales. Twenty-four tags were deployed on blue whales between 03 August and 12 September 2014. Locations were received from 22 of these tags, providing tracking periods ranging from 0.7 to 144.2 days. There was a great deal of individual variation among blue whale tracks, both in terms of distance to shore and latitudinal movement along the coastline. The continental shelf break between Dume and Mugu canyons (where all blue whales were tagged during the first leg of the cruise) and the Santa Monica Canyon was heavily used throughout August. There was also extensive movement north and south from the tagging area by some whales during this same period, with two reaching Cape Mendocino in northern California and three others crossing into Mexican waters by the third week of August. There was also extensive movement off San Diego, where whales were tagged during the second leg of the cruise. By the end of September, the blue whales were spread out between the area off Magdalena Bay in southern Baja California and the tip of the Olympic Peninsula in Washington. By mid-October all whales were traveling south, with the northernmost departure point at the northern tip of Vancouver Island, British Columbia. By mid-November, all five whales still being tracked were south of the U.S./Mexico border, with three of them having crossed south of the Mexico/Guatemala border. Only two tags continued to transmit after mid-December, both whales spent the months of December and January in the Costa Rica Dome upwelling area.

None of the tagged blue whales were tracked within the Gulf of Alaska. Two blue whales had locations inside both SOCAL and NWTRC/NWTT areas. Two other whales had training range locations only within NWTRC/NWTT and 16 had locations only within SOCAL. Of the four blue whales with locations inside the NWTRC/NWTT, only one had locations inside training area W237 (19 percent of its total locations). All locations within the training ranges were less than 225 km from shore in SOCAL and less than 125 km from shore in NWTRC/NWTT for all but one whale. The exception was tag 847 that had maximum distances from shore of 621 km within SOCAL and 287 km within NWTRC/NWTT. Blue whale locations occurred in both SOCAL and NWTRC/NWTT in 4 of the 6 months in which whales were tracked (August, September, October, and November). Locations inside training area W237 of the NWTRC/NWTT occurred only in August, September, and October.

With the close proximity of tagging locations to SOCAL, it is not surprising that blue whales spent time there, with 18 blue whales having locations inside SOCAL. Fewer than 50 percent of the locations for these 22 whales were in the SOCAL area and six blues had no locations in SOCAL at all. Time of year for these locations was a likely contributing factor, and it is possible that more locations/whales would be seen in the SOCAL area if tagging took place earlier in the feeding season or if tags lasted into the whales' southward migration.

***Fin Whales*.** Six tags were deployed on fin whales between 03 and 15 August 2014. Locations were received from all tags, providing tracking periods ranging from 4.9 to 143.7 days. After spending time in the inner Southern California Bight waters, fin whale movement was predominantly directed offshore, beyond the Channel Islands. Three whales then traveled north beyond Point Conception. The three ADB tags all stopped transmitting by 25 August, according to their pre-determined deployment period. By mid-September, the three whales equipped with SPOT-5 tags were spread out between SCI in Southern California and the Oregon/California border. One of these latter whales spent the remainder of its tracking period between the outer

Channel Islands and Monterey Bay, before its tag stopped transmitting at the end of October. Another whale traveled extensively throughout the southern and central California coast before heading south into Mexican waters by the beginning of November. This whale then moved back and forth between Southern California and the central Baja California coast before its tag stopped transmitting on 24 December.

None of the tagged fin whales were tracked within the Gulf of Alaska. Four fin whales had locations within SOCAL, and one had locations within the NWTRC/NWTT (**Figure 20**). There were no fin whale locations inside training area W237 within the NWTRC/NWTT. The maximum distance from shore for these locations was 83 km within SOCAL and 72 km within NWTRC/NWTT. Fin whale locations occurred in SOCAL in all 5 months in which they were tracked (August, September, October, November, and December), but only 2 months in NWTRC/NWTT (August and September).

3.2.4.2 ADVANCED DIVE BEHAVIOR TAGS

These data offer an unprecedented ability to observe how the diving behavior of a blue or fin whale changes spatially and temporally at high spatial and temporal resolution, and will allow us to see how consistent those behaviors are across individuals and species (**Figures 21 and 22**). The general dive behaviors recorded by these ADB tags (showing that the whales tended to dive deeper, and forage more, during the day) are consistent with the published literature; however, the observed variability between tagged individuals, even when they are in close proximity to each other, suggests that foraging behavior in baleen whales is more complex at the scales sampled by these tags than previously documented. The behavioral differences between individuals may represent different energetic requirements or foraging strategies between the whales.

While there was a clear diel pattern observed in the data, a non-negligible amount of foraging dives occurred at night, when the whales are generally thought to be resting or otherwise not engaged in feeding. While it is not unknown for blue whales to forage at night, there is relatively little information about it in the literature. These data offer the chance to see where the night time foraging was occurring and what kind of behavior led up to the nighttime foraging events. A number of the nighttime foraging events recorded by the ADB tags occurred in the hours prior to sunrise or after sunset. Dive profiles from those time periods show the bottom depth of recorded dives ascending or descending in the water column. This phenomenon has been shown to be the result of the whale following the diel vertical migration of the deep scattering layer as it either ascends or descends in the water column. It may be that if prey is dense enough, the whales can continue to forage at night, after it has migrated up the water column. The long-term behavior data can help address that question by looking at the intensity of the foraging effort leading up to and following the nighttime feeding effort.

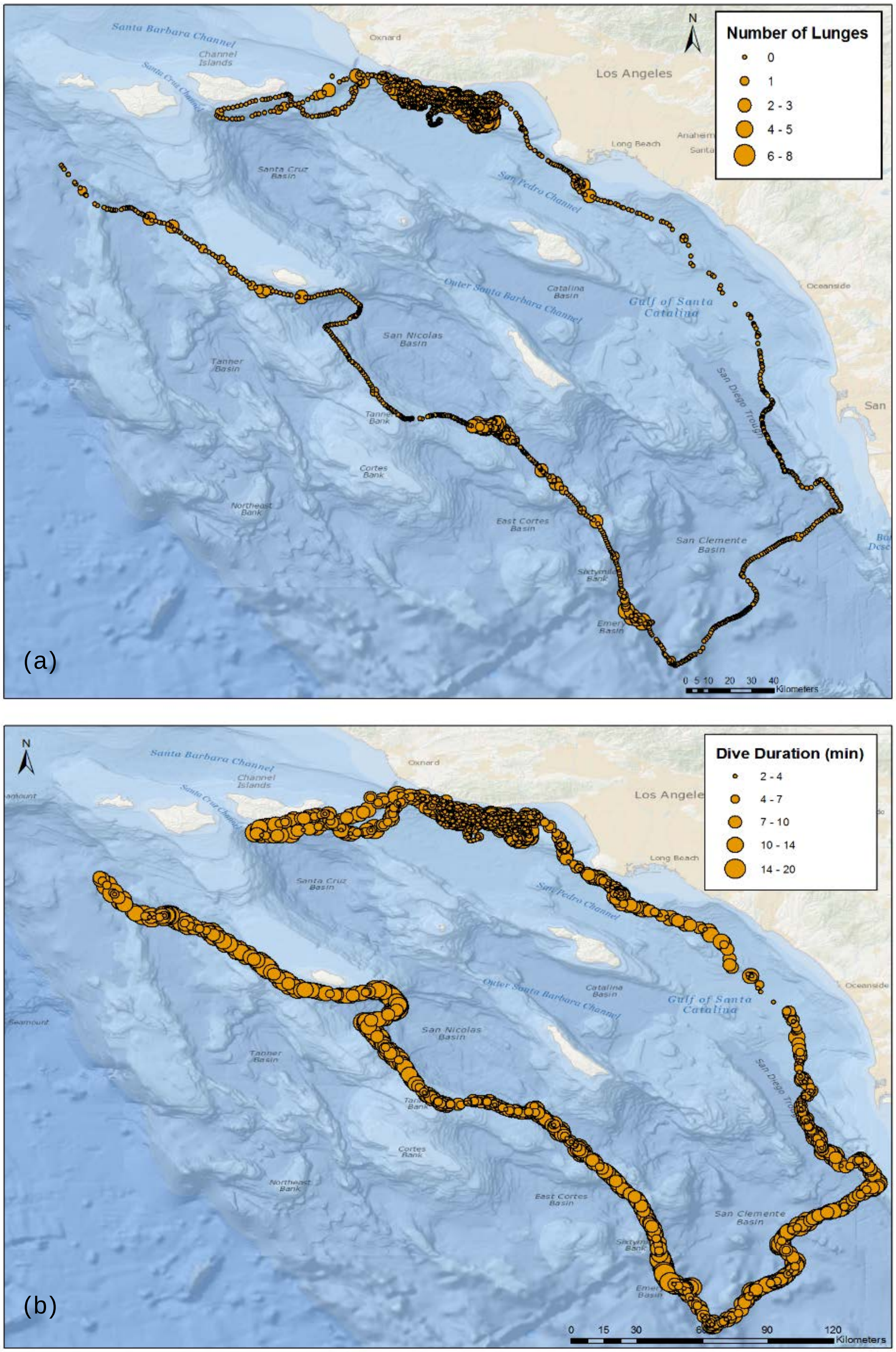

Figure 21. Track of an ADB-tagged blue whale (#5650) tagged off Southern California, 2014: by dive duration (N_{dives}=2276) (a) and by number of lunges (b). Date range shown in both panels is from 04 August through 23 August 2014. (Source: Mate et al. 2015 [4], used with permission.)

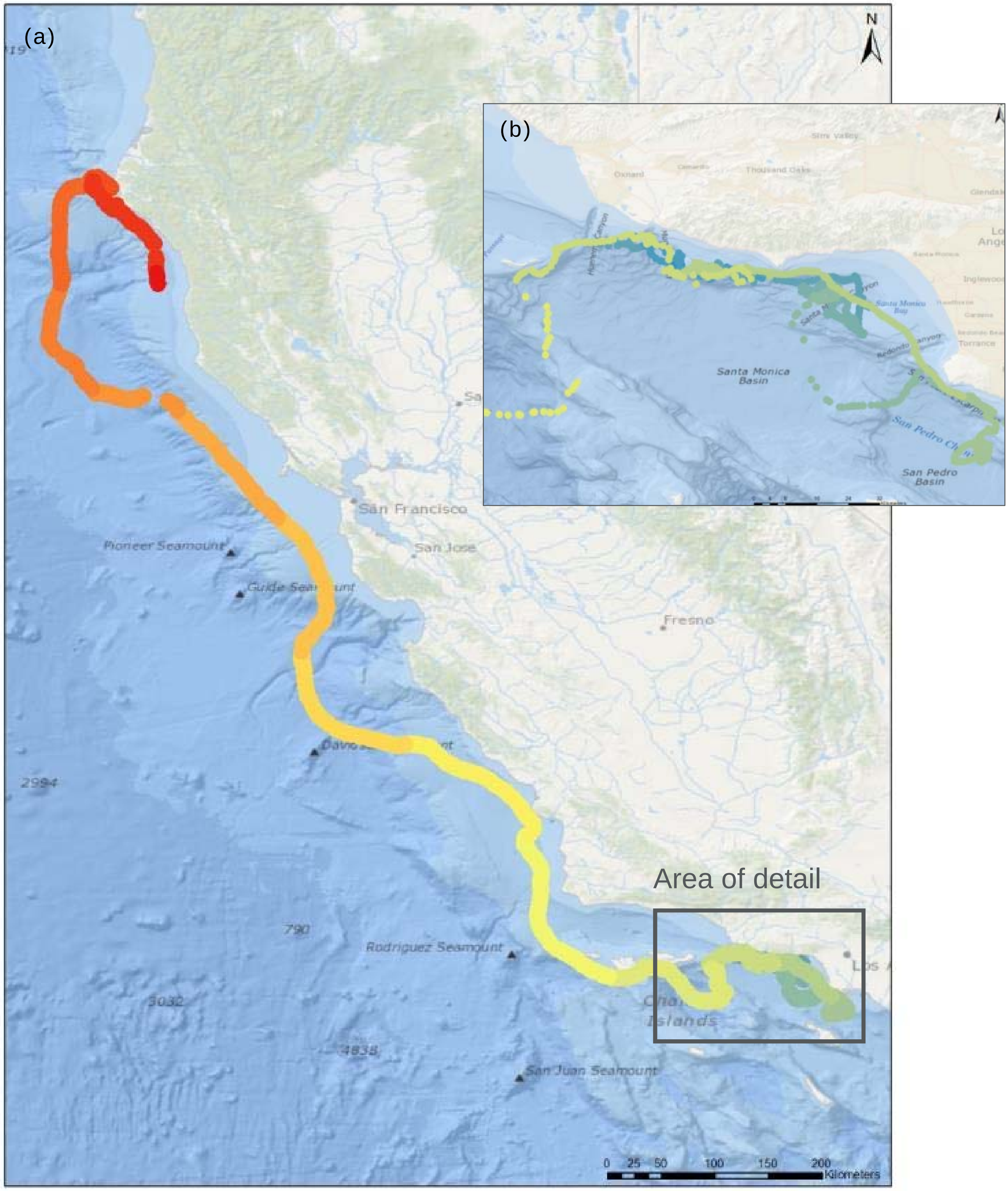

Figure 22. Track of an ADB-tagged blue whale (#5803) tagged off Southern California, 2014. The date range shown is from 4 August through 23 August 2014. (Source: Mate et al. 2015 [4], used with permission.)

3.2.5 Project 6: Blue Whale, Fin Whale, Humpback Whale, and Cuvier's Beaked Whale/Vocalization/Echolocation and Impact Assessment from Anthropogenic Sounds

Monitoring Question: What are the anthropogenic sound impacts to blue whale, fin whale, humpback whale, and Cuvier's beaked whale vocalization and echolocation?

[6a] Debich et al. 2015a

Sounds from six baleen whale species were recorded: blue whale, Bryde's whale, fin whale, gray whale, humpback whale, and minke whale. Across all sites, fin and humpback whales were the most commonly detected baleen whales. The Northeast Pacific blue whale B call is a geographically distinct call possibly associated with mating functions (McDonald et al. 2006, Oleson et al. 2007). Also detected were blue whale D calls, which are similar worldwide and are associated with feeding animals; they may be produced as call-counter call between multiple animals (Oleson et al., 2007). Blue whale B calls and Bryde's whale calls peaked in fall months, while blue whale D calls peaked in summer months. Fin whale 20-Hz calls peaked in winter and spring months, while fin whale 40-Hz calls peaked later in summer. Humpback whale calling peaked in late December through January. The only gray whale call type detected was the M3 call, which is a low-frequency, short moan, and the most common call produced by migrating gray whales (Crane and Lashkari 1996). Gray whale M3 calls were detected in small numbers at each site, primarily in the winter and spring. Minke whale boings were detected at all sites in small numbers except for site M.

Signals from seven odontocete species were detected: Risso's dolphin (*Grampus griseus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), killer whale (*Orcinus orca*), sperm whale, Baird's beaked whale (*Berardius bairdii*), Cuvier's beaked whale, and an unknown beaked whale species identified as BW43. Neither Blainville's beaked whales nor Stejneger's beaked whales (*Mesoplodon stejnegeri*) were detected. Cuvier's beaked whale frequency-modulated pulses were common at every site and were the most commonly detected beaked whale sound. Baird's beaked whales were detected in low numbers during summer months at sites M and N. Site N was the only site at which BW43 pulses were detected, albeit in low numbers.

The following anthropogenic sounds were detected: broadband ship noise, echosounders, explosions, underwater communications, low-frequency active sonar (LFAS), MFAS, and a previously undescribed sound near 180 Hz. Explosions were detected at all sites, and characteristics of the explosive sounds suggest association with fishing. A previously undescribed anthropogenic signal at 180 Hz was detected at site N, with peaks in detections occurring in January 2013.

[6b] Debich et al. 2015b

Passive acoustic monitoring was conducted in SOCAL from January to July 2014 to detect marine mammal and anthropogenic sounds. HARPs recorded sounds between 10 Hz and 100 kHz at three locations: west of SCI (1,000 m depth, site H), southwest of SCI (1,200 m depth, site N), and west of La Jolla, California (550 m depth, site P). Sites H and N are located offshore, whereas, site P is located nearer to the coast (**Figure 14**).

Data analysis was performed using automated computer algorithms, augmented with analyst scans of long-term spectral averages and spectrograms. Calls of three baleen whale species were detected using automatic algorithms: blue whale B calls, fin whale 20 Hz calls, and humpback whale calls. All three species were present at all sites but least common at site P. Blue whale B calls increased in June and July but were detected during all months. Fin whale acoustic index, representative of 20 Hz calls, was high during January–April. Humpback whale calling peaked in March–April at site H and in January at site P.

Frequency modulated echolocation pulses from Cuvier's beaked whales were regularly detected at sites H and N, but not at site P. These detections peaked in April and June. There was an additional beaked whale-like frequency modulated pulse type, BW43, possibly produced by Perrin's beaked whales, detected infrequently and only at site N. No other beaked whale signal types were detected.

MFAS was detected at all sites. Sites P and N had the highest maximum received levels, but site P had the fewest number of MFAS packets. Site N had the most MFAS packet detections and highest cumulative sound exposure levels concurrent with major naval exercises during May–June, while site H had the lowest maximum RLs and SELs. Explosions were detected at all sites, but were most prevalent at site H. Explosion detections peaked in June across sites. Temporal and spectral parameters, RLs, and the nighttime pattern of these explosive events suggest association with fishing, specifically the use of seal bombs.

[6c] Wiggins et al. 2015

A new method was developed to provide better metrics for quantifying MFAS occurrence and levels, which was applied to PAM data collected in SOCAL during March 2009 to January 2014. MFAS signals are composed of both tones and frequency-swept 'pings,' often with multiple pings grouped closely in time as packets. These packets often occur repeatedly at intervals >20 seconds over periods of hours as wave train events with gaps between events >1 hr.

The new method calculates MFAS packet peak-to-peak (pp) RLs, but additional metrics, not included in previous analyses, are computed such as RMS levels, SELs and signal duration. The new approach uses a higher RL packet detection threshold (130 dBpp re 1 μPa) than previous analyses, which limits the detection range to about 20 km, reducing the number of overall detections but also reducing the false detection rate. Furthermore, the results from this new method were provided as a comprehensive review over the 5-year monitoring period in the SOCAL, showing longer term trends than the previous individual reports.

MFAS was recorded in SOCAL from March 2009 to January 2014 using HARPs deployed at three sites: (1) Site M, located in the eastern Santa Cruz Basin, north of SCI, (2) Site H, located in the western San Nicolas Basin, west of SCI, and (3) Site N, located in the East Cortez Basin, south of SCI. Site M had the lowest MFAS activity compared to the two sites south. Only 10 wave train events of MFAS were detected at site M; whereas, site H had 151 events and site N had 310 events. On average, wave train events consisted of over 100 MFAS packets with most packet durations < 4 seconds. In 2009, a few events were comprised of over 1,000 packets, although most events had less than 600 packets, and throughout 2013, the number of MFAS packets per event appeared to decrease at sites H and N.

CSEL for each wave train event was calculated as the sum of the packet SELs. This provides a measure of the total energy emitted during an event, a useful metric for marine mammal impact studies. Site N had the highest CSELs with values approaching 180 dB re 1 µPa2-s and site H had some CSELs over 170 dB re 1 µPa2-s, but site M had only two events with levels over 160 dB re 1 µPa2-s.

Further enhancements to this new approach for quantifying MFAS activity will be developed in conjunction with marine mammal impact studies. For example, efficiencies can be gained by reducing the number of analysts needed to define wave train events by implementing computer automated methods, and additional parameters, such as packet frequency content, will be measured to investigate if these are important factors for potential marine mammal impacts.

3.2.6 Project 7: Fin Whale and Cuvier's Beaked Whale Vocalization/Echolocation and Impact Assessment from Anthropogenic Sounds at Navy's Southern California Offshore Antisubmarine Warfare Range (SOAR)

Monitoring Question: What are the anthropogenic sound impacts to fin whale and Cuvier's beaked whale vocalization and echolocation within the Southern California Offshore Antisubmarine Warfare Range (SOAR)?

[7a] Falcone and Schorr 2014

In terms of population assessments, work funded previously under the U.S. Navy's Living Marine Resources program was summarized this year based on field efforts from June 2010 to January 2014. Detailed annual progress reports were prepared after each survey year through 2013 and are available online through the Naval Postgraduate School. Falcone and Schorr (2014) analyzed combined data across study years, particularly with respect to two focal species: Cuvier's beaked whale and fin whale. Overall from 2010 to 2014, 18 cetacean species were encountered in small-vessel surveys based at SOAR, and several previously documented seasonal trends in species occurrence were confirmed. Fin whales were sighted in every month surveyed, and Cuvier's beaked whales were sighted in all months but one, suggesting both species are present year-round. Preliminary mark-recapture abundance estimates from photo-identification data suggest both species have local populations in the low hundreds. Both photo-identification and telemetry data suggest Cuvier's beaked whales exhibit a degree of basin-specific site fidelity within Southern California. Many fin whales also appear to preferentially remain within Southern California year-round, with increased use of nearshore waters in fall and winter. A subset of 688 hr of Cuvier's beaked whale diving behavior (from periods without MFAS) in the area showed that the behavior of these whales was similar to that of the larger dataset (including sonar exposure), and confirms previous observations that Cuvier's beaked whales here appear to forage less often than whales in other regions, and that sonar exposure is unlikely to be the primary driver of these regional differences, though some exposures may cause foraging disruption. Future research will seek to further elucidate the relationship between behavioral patterns and sonar use in the area.

[7b] Moretti 2015

Significant improvements were made in the development of classification and localization algorithms for Cuvier's beaked whales. The Jarvis Support Vector Classifier, effective at classifying this species, has been ported to the system, allowing for the development of semi-automated tools designed to identify groups of Cuvier's beaked whales, to provide density estimates, and to map species habitat. Cuvier's beaked whale detections from 2012 were analyzed manually, resulting in an initial density estimate of approximately 26 animals/1,000 km^2. Density estimation for 2013 and 2014 is underway. Eight months of 2013 M3R detection archives were analyzed for group vocal periods. Data indicated a reduction in abundance during the summer, with a minimum in August. These data are being combined with the mean group size derived from on-site sighting data and mean dive rate derived from satellite tag data. In 2014, a new Argos receiving station was beta-tested with positive results. Analysis of U.S. Navy sonar logs (records of sonar use from the times and locations that tags are active) will be limited to instances of sonar use on or near SOAR, where transmissions can be verified using passive acoustics (2010 to 2011 are nearly completed, 2012 to 2013 are in process). Identification photographs from Cuvier's beaked whales and fin whales were collected, processed, and integrated into existing catalogs. These data will be used to refine population estimates and stock identity, assess site fidelity (a key parameter in understanding cumulative population level impacts), and describe demographics, such as reproductive rates. This study has documented the persistent presence of Cuvier's beaked whales in an area of repeated sonar use, and suggests these whales may actually be part of a smaller regional subpopulation rather than transient members of a large and dispersed U.S. West Coast population.

In addition to the development of detection algorithms, and ground-truthing acoustic data with sighting and tag data, in 2014 the M3R team initiated development of a risk function to estimate behavioral disturbance of Cuvier's beaked whales from MFAS. Data inputs to the risk function include 2013 and 2014 sonar operations and ship tracks, M3R species detection archives, and sonar data derived from acoustic archives. By combining passive-acoustic data with ship-track data, a risk function can be derived which maps the probability of disturbance (e.g., cessation of foraging) to a RL of sound.

3.2.7 Project 8: Marine Mammal Visual Sightings during Seasonal California Cooperative Oceanic Fisheries Investigations (CalCOFI)

Monitoring Question: What are the spatial and temporal patterns of marine mammal occurrence in Southern California?

[8a] Campbell et al. 2015

[8b] Douglas et al. 2014

The objectives of this effort are the continued visual and passive acoustic collection of marine mammal sightings during quarterly California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises. The main goal is to improve understanding of Southern California marine mammal density, occurrence, and trend information. Data will be integrated to the best extent practical into ongoing spatial habitat modeling using NMFS' Southwest Fisheries Science Center's model. For over a decade, the U.S. Navy has funded collection of marine mammal sighting data and passive acoustic detections during quarterly CALCOFI vessel cruises through

Southern California (http://www.calcofi.org/index.php). While CALCOFI is one of the longest running fisheries and oceanographic series (starting in 1949), U.S. Navy-funded marine mammal survey effort began in 2004, the same year CalCOFI also became part of the Long Term Ecological Research Ecological Studies Network.

The U.S. Navy's Chief of Naval Operations Environmental Readiness Division R&D Program which later transitioned into the Living Marine Resources program funded CalCOFI marine mammal data collection from 2004 to 2010. U.S. Pacific Fleet has funded data collection since 2011, and plans to fund through 2016. Results presented in CalCOFI reports provide supporting data for SOCAL annual reporting from 2011 to 2013. In 2014, various authors associated with the CalCOFI field effort took a cumulative look at the data and, given the large number of sightings obtained, were able to publish both small-scale density updates (Douglas et al. 2014) as well interannual variability and population trends (Campbell et al. 2015).

For 16 visual line-transect surveys conducted between 2004 and 2008, Douglas et al. (2014) seasonal (summer-fall/winter-spring) and spatial (water depths <2,000 m/water depths > 2,000 m) densities were calculated for 11 species, including ESA-listed blue, fin, humpback, and sperm whales; and seven of the more commonly encountered small cetacean species (short-beaked and long-beaked common dolphins [*Delphinus delphis* and *Delphinus capensis*, respectively], Pacific white-sided dolphin, Risso's dolphin, bottlenose dolphin, northern right whale dolphin [*Lissodelphis borealis*], and Dall's porpoise [*Phocoenoides dalli*]). The fin whale was the most commonly encountered baleen whale and was sighted year-round.

Trends in cetacean density and distribution from CalCOFI data collected during 2004 to 2013 was assessed by Campbell et al. (2015). Blue whales, fin whales, and humpback whales were the most frequently sighted baleen whales. Short-beaked common dolphins, Pacific white-sided dolphins, and Dall's porpoise were the most frequently encountered small cetaceans. Annual density estimates were calculated for blue and fin whales. Blue whales were primarily observed during summer and fall (**Figure 23a**) while fin whales were observed year-round with more sightings during summer (**Figure 23b**). Campbell et al. (2015) concluded there were no significant long-term changes across the 10-year study in blue whale, fin whale, humpback whale, short-beaked common dolphin, or Dall's porpoise densities. However, Pacific white-sided dolphins did show a significant decrease in density across the same period.

Data from marine mammal sightings during CalCOFI are being integrated by NMFS' Southwest Fisheries Science Center into Navy-funded revisions to their species-specific spatial habitat models.

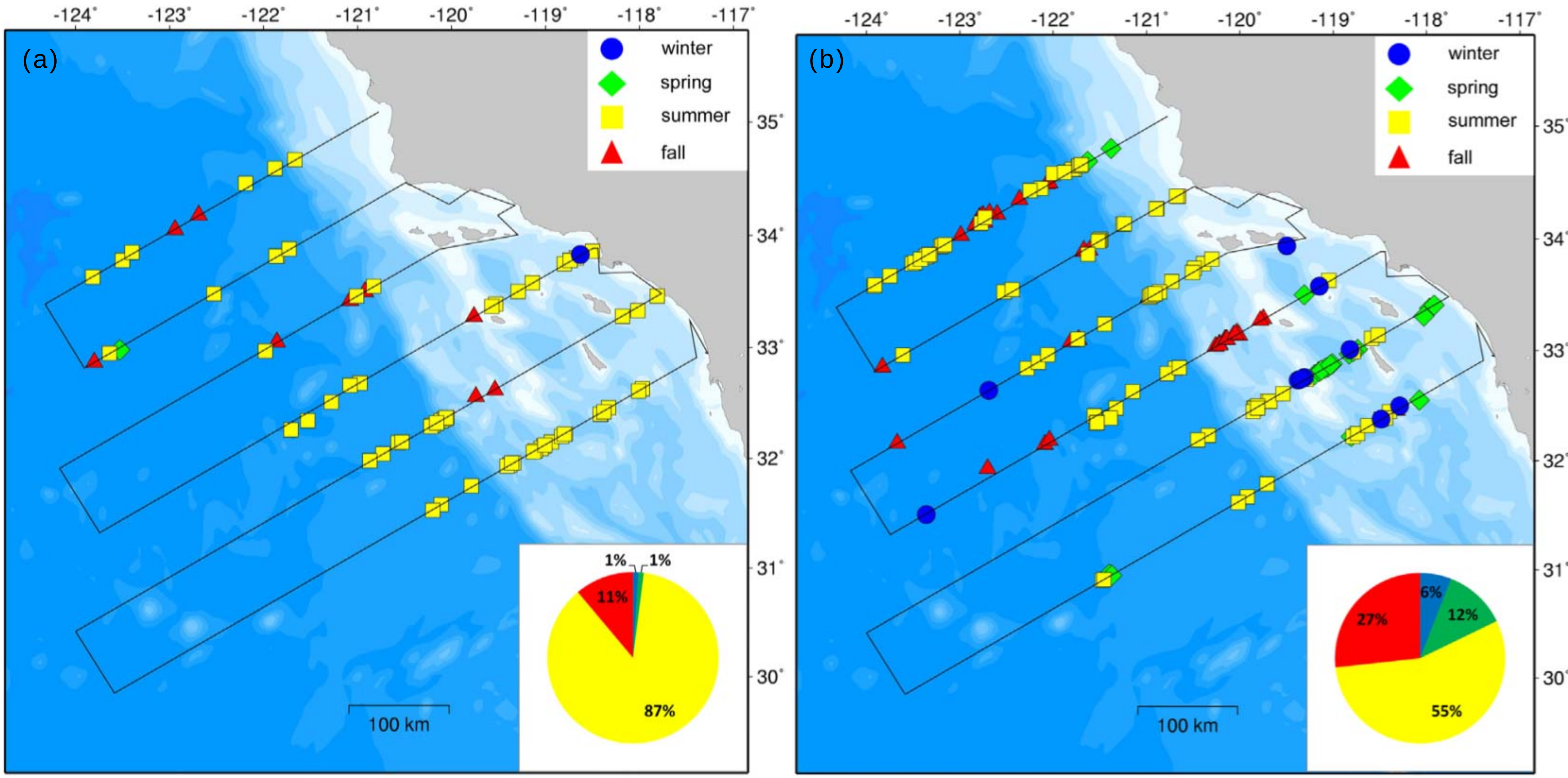

Figure 23. On-effort visual detections of blue whales (a) and fin whales (b) by season in the CalCOFI study area from 2004 to 2013. (Source: Campbell et al. 2015 [8a] used with permission. Pie charts show percentage of sightings that occurred in each of the four defined seasons: winter=blue, spring=green, summer=yellow and fall=red)

3.3 Cumulative Comparison of 2014 SOCAL Monitoring Data to Previous Years

There has been continued effort to address intermediate scientific objectives and regional study questions as envisioned at the start of the HSTT monitoring in 2014, and as refined for 2016 in this report (see **Section 4**).

For SOCAL, 2014-2015 represents the beginning of a transition away from earlier monitoring metrics, which were heavily weighted toward baseline occurrence using visual surveys and passive acoustic monitoring (2008-2013). U.S. Navy marine mammal research has been conducted in SOCAL since 2006 under funding from the Living Marine Research Program. The program continues to mature and evolve closer to compliance monitoring applicability, whether for baseline population assessments or impact assessment (Falcone and Schorr 2014, Moretti 2015).

In some cases, SOCAL 2014 projects and associated methods described in this report represent a continuation of projects from previous years. Examples include long-term PAM on and off the SOAR instrumented range (Debich et al. 2015a,b and Moretti 2015), and broad spatial and temporal coverage of marine mammal sighting data from CalCOFI cruises (Campbell et al. 2015 Douglas et al. 2014). In another case, a new start project for 2014, Blue and Fin Whale Tagging in SOCAL, represents a departure from previous years in order to expand the scope of species-specific information. This effort involves satellite tracking of individual blue and fin whale movements and regional residence times over weeks and months (Mate 2015).

While baseline information continues to be accumulated and assessed (e.g., Soloway and Dahl 2014, Debich et al. 2015a,b, Graham and Saunders 2015), there will be a stronger focus on improving the state of science for impact assessments going forward (Moretti 2015, Wiggins 2015). To facilitate this analysis and focus on species of particular interest to NMFS and the U.S. Navy, three key species within SOCAL have been designated for continued baseline and effects analysis: blue whales, Cuvier's beaked whales, and fin whales.

***Continued Baseline Monitoring*.** Campbell et al. (2014), Douglas et al. (2014), Debich et al. (2015a,b), and Graham and Saunders (2015) report on the most commonly observed marine species in SOCAL. In general, the occurrence, seasonality, and abundance of these species remain similar to previous U.S. Navy reporting. Campbell et al. (2015) summarized a 10-year window of CalCOFI marine mammal sighting data noting no significant long-term changes in blue whale, fin whale, or humpback whale densities. Debich et al. (2015a,b) results from long-term bottom-mounted PAM off range are consistent with previous reporting from 2009–2013. This includes typical cetacean species and anthropogenic sounds such as MFAS and explosions. These accumulated and continuing passive acoustic data sets will serve as the foundation for future effects analysis. Of note, the large quantity of small explosions, many at night, detected over the years cannot be attributed to the U.S. Navy's use of explosives and are likely from fishery-related use of pinniped deterrents. Scripps Institution of Oceanography and NMFS' Southwest Fisheries Science Center reported on this assessment in support of the U.S.

Navy's 2013 SOCAL Annual Monitoring Report (Baumann-Pickering et al. 2013), as well as continued detections reported in Debich et al. (2015a, b).

New Monitoring. The first Fleet-funded large whale tagging project in SOCAL started in 2014. Blue and fin whales were instrumented with satellite tags off Southern California in order to better understand the long-term (weeks to months) movements and habitat use of these whales in Navy range areas along the U.S. Pacific Coast (Mate 2015). From August to early September 2014, 29 tags were successfully attached. Most initial tag attachment locations were just north of the SOCAL Range Complex near Point Dume, California (north of Santa Monica Bay). Tags attached included: 20 location-only tags on blue whales, three location-only tags on fin whales, four Advanced Dive Behavior tags on blue whales, and two Advanced Dive Behavior tags on fin whales. Cumulative species-specific movement by all tagged animals from 2 August 2014 through 9 March 2015 resulted in 71,522 km (38,619 nmi) traveled by blue whales, and 15,721 km (8,489 nmi) traveled by fin whales. Out of the 20 blue whale location-only tags, one tag was still transmitting after six months (through 9 March) from a blue whale in the Eastern Tropical Pacific approximately 8–10 degrees from the equator. Blue whale movements with the majority heading south much earlier than previous research (Mate et al. 2009, Irvine et al. 2014) was likely heavily influenced by the extreme warm sea surface temperatures along the U.S. West Coast during the summer and fall of 2014. While Mate (2015) summarized results from this first season of tagging, this study is envisioned to continue for several years, and planning efforts for a spring-summer 2015 field season are in progress.

***Navy Research Transition*.** The U.S. Navy's Living Marine Resources Program funds several ongoing projects at the underwater instrumented range at SOAR. Beginning in August 2006, species verification tests were begun at SOAR where expert observers in small boats were vectored to vocalizing animals isolated with M3R passive acoustics, to determine the species, group size, and behavior of the animals (Falcone et al. 2009; Falcone and Schorr 2011, 2012, 2013, 2014). The initial goal of these surveys was to adapt the existing M3R system, which presented technical challenges due to differences in the design and layout of the array and the much higher diversity and abundance of vocal species in the region (Falcone et al. 2009). With the 2010 installation of new hydrophones with low-frequency capability, the M3R system was expanded to provide low-frequency monitoring (for detection of baleen whale calls) (Moretti 2012, 2015). Field efforts were conducted during 11–24 November 2009 and 14–30 June 2010 to provide visual verification of passive acoustic detections (DoN 2010b). Since then, field efforts involving M3R have evolved to focus on beaked whales and ESA-listed baleen whale species (in particular, the fin whale) using an integrated approach to include photo-identification, detailed surfacing behavior observations, genetic sampling, and deployment of satellite tags to collect data on both movement patterns (and in some cases, dive behavior) (e.g., Falcone and Schorr 2011, 2012, 2013, 2014; Moretti 2012, 2015). Both Falcone and Schorr (2014) and Moretti (2015) report on progress to date. In 2013 and 2014, the M3R team developed a set of prototype passive acoustic tools to estimate Cuvier's beaked whale density, and document the spatial and temporal reaction of cetaceans to sonar training and testing. These cetacean detections, now focused on Cuvier's beaked whales (and eventually fin whales), can be combined with ship track data and sonar data obtained from SOAR range hydrophones to estimate RLs using a species-specific risk function (Moretti 2015). Falcone et al. (2009) noted that as the M3R system is further refined, PAM may provide a more standardized means of estimating density within this study area than visual surveys can provide. In addition, by combining multiple technologies (e.g., M3R detections, visual sightings, tagging, photo-identification, and genetic sampling), Falcone and Schorr (2014 continue to advance the state of knowledge on key population vital rates for Cuvier's beaked whales and fin whales. U.S. Pacific Fleet and the Living Marine Resources program maintain close coordination to determine which elements of M3R including other associated efforts (e.g., short-term tagging and photo-identification) are suitable for full transition to U.S. Pacific Fleet compliance monitoring vice research funding. This dialogue is expected to continue through 2016.

As currently envisioned, M3R will remain under mostly Living Marine Resources funding in 2015, transitioning toward reportable data products under U.S. Pacific Fleet funding in 2016. Specific focus areas for M3R can include, but are not limited to, the following:

Derivation of Population Health Metrics for Cuvier's Beaked Whales

1. Develop and validate passive acoustic detectors/classifiers in situ.
2. Map the species' acoustic behavior to physical behavior using passive acoustic and recording tag data.
3. Measure the reaction of animals to sonar with a focus on foraging dives.
4. Develop and test method for long-term continuous estimation of abundance.
5. Collect both ship tracks and sonar data to estimate the sound field and RLs with and without sonar.
6. Develop a behavioral risk function to estimate disturbance.
7. Establish group size and population structure via visual observation.
8. Measure dive behavior and sonar reaction via mid-term satellite tags.
9. Establish a comparative site with little or no sonar use.
10. Develop and implement a Potential Consequences of Disturbance model for population level effect by combining passive acoustic animal and sonar data, visual sightings, ship tracks, and tag data.
11. Use comparative sites as a means of validation.

To extend these measurements to a population model, additional visual and satellite tag data will provide the following:

1. Animal movement both on and off range in reaction to sonar.
2. Baseline foraging dive behavior including dive rate, depth, duration.
3. Foraging dive behavior in response to sonar (dives lost).
4. Group size.
5. Group composition with a focus on the ratio of adult females to calves and juveniles.

Define Long Term Abundance, Distribution, and Density for Cuvier's Beaked Whales

The M3R program has detected Blainville's beaked whales at the Navy's Atlantic Undersea Test and Evaluation Center (AUTEC) and PMRF and Cuvier's beaked whale at AUTEC and SOAR. Detections were made using passive acoustics, and visually verified by expert observers.

Beaked whales associate and dive together in groups, executing deep foraging dives at measurable rates and echolocate only during these dives. Therefore, the detection of beaked whale echolocation clicks indicates a group of animals in a deep foraging. If the mean group size and foraging dive rate is known, animal abundance and density can be readily estimated.

Using the dive counting method developed for Blainville's beaked whales at AUTEC, the M3R capability will initially provide long-term monitoring of beaked whales on all three major ranges. Tracking trends in abundance over months, seasons, and years will be possible as data become available. Interestingly, as stated above, initial Cuvier's beaked whale abundance estimates at SOAR over nearly a continuous year of data suggest a reduction in the number of animals during summer months reaching a low in August. This is a preliminary measurement and is only for one year.

In another study also based on limited data, Moore et al. have suggested that the population of beaked whales is in decline in Southern California waters but make no mention of, or allowance for, possible seasonal variations. These findings highlight the need for long-term, continuous monitoring. Over time, M3R passive acoustic data will be able to provide a more robust long-term Cuvier's beaked whale abundance estimate for SOAR. Such estimates can be cross-validated with those produced using existing photo-identification data via mark-recapture methods. Additionally, the dive counting method requires an estimate of group size and dive rate. Cuvier's beaked whale group size is being derived at SOAR from visual sighting data from collaborating on-water partners as summarized in Falcone and Schorr 2014. Dive rate is being measured via depth recording mid-term satellite tags.

Beaked whale deep foraging dives can be used as a proxy for animal distribution. Collection of long-term data provides the ability to map animal distribution throughout the year and over multiple years. These data can also be used in conjunction with ancillary studies such as those currently underway to map prey distribution to inform and validate habitat models.

These methods are not restricted to beaked whales but can be adapted as the in-situ call rate statistics become available for other species including large baleen species. For example fin whales are routinely detected and localized on SOAR and recently detected and visually verified at PMRF. If the call rates for fin whales are known, passive acoustic density estimation methods can be developed keeping in mind rates may vary between sexes, seasons, locations, and environmental conditions. However, for large baleen species validation of passive acoustic methods via visual surveys is straightforward as compared to cryptic beaked whale species.

Define Cuvier's Beaked Whale Reaction to Sonar

Passive acoustic methods are being used to document the movement of beaked whales on the instrumented range in response to active sonar. The data suggest the animals move off-range when exposed to MFAS and return within days after the cessation of training events (McCarthy et al. 2011; Tyack et al. 2011). The strength of the reaction may vary depending on the sonar type and the total time duration of the operation. M3R passive acoustic methods are restricted to the instrumented ranges. To complete an analysis of cumulative effect of repeated sonar exposure, it is important to understand animal behavior off-range. This includes the total displacement, the nature of the off-range movement, the number of foraging dives lost, and the density/qualities of prey both on and off the range. Depth recording satellite tags provide a means of measuring the nature of the movement off-range, the total displacement, and most importantly if foraging dives were lost (Falcone and Schorr 2014, Schorr et al. 2014).

Measuring prey distribution requires prey mapping of mesopelagic and benthic species (Benoit-Bird et al. 2009, 2013). This presents significant challenges considering the animals forage at extreme depths often in excess of 1,000 m. The Office of Naval Research is sponsoring the development of a deep diving Autonomous Undersea Vehicle, which is being tested at both SOAR and AUTEC. M3R passive acoustic beaked whale detection data are being collected using the range hydrophones during these trials. These data are being combined with prey data to inform both habitat use models and for analysis of animal movement off-range.

Development of a New Cuvier's Beaked Whale Risk Function

As discussed above, a method to estimate Blainville's beaked whale foraging dives was developed with AUTEC data (Moretti et al. 2010, Marques et al. 2013). The baseline probability of foraging dive starts on range was calculated ahead of an operation with no sonar present. This was compared to the probability of foraging dive starts as a function of RLrms during three days of intense sonar operations. To calculate RLrms, M3R detection data were used to determine precisely when ships were transmitting sonar. These data were combined with ship track data in a propagation model and the RLrms for each detected Blainville's beaked whale foraging group was estimated. These data were then used to estimate the probability of a foraging dive at a given level of sonar. These were compared to the baseline value to determine the probability of a dive disruption as a function of RLrms. A parametric equation was then derived to describe this relationship, and a transfer function of Risk of Disturbance versus RLrms was developed (Moretti et al. 2014).

This method is being adapted to Cuvier's beaked whales at SOAR. Software to extract Cuvier's beaked whale foraging dives from M3R detection archives is currently being developed. Preliminary group detection statistics based on M3R archives have been measured and are being incorporated into the estimate. By adapting the Blainville's beaked whale method described above (Moretti et al. 2014), a Cuvier's beaked whale risk function can also be developed.

Conclusions. In 2014, the SOCAL monitoring program began focusing on region-specific study questions and associated projects. It is envisioned that a core of projects described in this report will continue as the foundation for 2015–2016 SOCAL monitoring (see Section 4). Funding for two of the passive acoustic associated efforts, further refined and discussed in Section 4, occurred late in fiscal year 2014. Therefore, those projects (off-range passive acoustic monitoring and impact assessment by Scripps Institution of Oceanography, and SOAR M3R transition) have only just gotten underway at the end of 2014 and beginning of 2015. The M3R program has a strong background from previous work done at AUTEC and ongoing data collection since 2008 at SOAR. New Cuvier's beaked whale data on population vital rates, abundance, distribution, sonar reaction, and risk function are all in development. Additional information and results from these two projects (on- and off-range monitoring) should be available in time for the U.S. Navy's 2016 HSTT Annual Monitoring Report.

Similarly in 2014, the first season of a planned multi-year field season was completed for a new blue and fin whale tagging project. Additional tagging results and analysis from 2015–2016 and possibly 2016–2017 will be combined with 2014–2015 results as the project progresses.

4. Adaptive Management and Yearly Monitoring Goals

4.1 AMR

AMR is an iterative process of optimal decision-making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. AMR takes place annually with NMFS and engages the Marine Mammal Commission and non-governmental organizations through technical review meetings.

Dynamic revisions to the Compliance Monitoring Structure as a result of AMR include the further development of the Strategic Planning Process, which is a planning tool for selection of monitoring projects, and its incorporation into the ICMP for future monitoring. Phase II monitoring addresses 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) is not a specific requirement, but instead the requirement on the U.S. Navy Marine Species Monitoring program is to pose, and make progress toward, addressing scientific monitoring questions.

The AMR process and reporting requirements serves as the basis for evaluating performance and compliance. In light of no longer evaluating the U.S. Navy's Marine Species Monitoring program via metrics of effort, the adaptive management process makes 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 Hawaii Range Complex Monitoring Plan (DoN 2008b) and SOCAL Range Complex Monitoring Plan (DoN 2009), which use the annual monitoring reports to inform adaptive management.

The Strategic Planning process is 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. Continuing or new monitoring starting in 2015-2016 within the HSTT area is currently listed on the U.S. Navy's Marine Species Monitoring web site:

http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/

4.2 2015–2016 HSTT Yearly Monitoring Goals

From 2015 to 2016 within HSTT, the U.S. Navy will continue many of the projects described previously in this report and presented in **Table 5**.

Table 5. 2015–2016 HSTT Monitoring Goals

Goal	Intermediate Scientific Objectives	Anticipated Methodology/ Budget *	Continuing or Proposed New Projects
Hawaii Range Complex			
Further our understanding of the Monitoring Question: *What are the long term trends in occurrence of marine mammals (e.g., minke, humpback, fin, Bryde's, Blainville's) on the PMRF range?*	• Determine what species and populations of marine mammals and ESA-listed species are present in U.S. Navy range complexes. • Develop and validate techniques and tools for detecting, classifying, and tracking marine mammals. • Develop and validate analytic methods to evaluate exposure and/or behavioral responses based on PAM techniques. • Evaluate trends in distribution and abundance for populations of protected species regularly exposed to sonar and underwater explosives. • Assess existing data sets which could be utilized to address the current objectives.	Analysis of archived PMRF hydrophone recordings $200,000	**PROJECT #1: Long-term Trends in Abundance of Marine Mammals at PMRF** *(New start)*
Further our understanding of the Monitoring Question: *What is the occurrence and estimated received levels of MFAS on 'blackfish', humpback, minke, sperm and Blainville's beaked whales within the PMRF instrumented range?*	• Determine what species and populations of marine mammals and ESA-listed species are exposed to U.S. Navy training and testing activities. • Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics, of marine mammals where U.S. Navy training and testing activities occur. • Develop and validate techniques and tools for detecting, classifying, and tracking marine mammals. • Assess existing data sets which could be utilized to address the current objectives.	PAM, tagging, photo-ID, biopsy, visual survey $300,000	**PROJECT #2: Estimation of Received Levels of MFAS on Marine Mammals at PMRF** *(Continuing)*

Goal	Intermediate Scientific Objectives	Anticipated Methodology/ Budget *	Continuing or Proposed New Projects
Hawaii Range Complex (continued)			
Further our understanding of the Monitoring Question: *What, if any, are the short term behavioral responses of 'blackfish,' humpback, minke, sperm and Blainville's beaked whales when exposed to MFAS/explosions at different levels/conditions at PMRF?*	• Determine what species and populations of marine mammals and ESA-listed species are present in U.S. Navy range complexes. • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where U.S. Navy training and testing activities occur. • Determine what behaviors can most effectively be assessed for potential response to U.S. Navy training and testing activities. • Develop and validate techniques and tools for detecting, classifying, and tracking marine mammals. • Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities. • Assess existing data sets which could be utilized to address the current objectives.	PAM, tagging, photo-ID, biopsy, visual survey $500,000	**PROJECT #3: Behavioral Response of Marine Mammals to Navy Training and Testing at PMRF** *(New start for some species, Continuing for others)*
Further our understanding of the Monitoring Question: *What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training events?*	• Determine what species and populations of marine mammals and ESA-listed species are present in U.S. Navy range complexes. • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where U.S. Navy training and testing activities occur.	Lookout Effectiveness Study Protocol $20,000-$40,000	**Project #4: Navy Civilian Marine Mammal Observers On MFAS Ships In Offshore Waters of the Hawaii Range Complex** *(Continuing)*

Goal	Intermediate Scientific Objectives	Anticipated Methodology/ Budget *	Continuing or Proposed New Projects
Southern California Range Complex			
Further our understanding of the Monitoring Question: *What are the occurrence, movement patterns, and residency patterns of blue and fin whales within Navy U.S West Coast at-sea ranges as compared to the rest of their distribution throughout the Pacific Ocean?*	• Determine what species and populations of marine mammals and ESA-listed species are present in U.S. Navy range complexes. • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where U.S. Navy training and testing activities occur.	Satellite tagging, photo-ID, biopsy, visual survey $600,000-$1,000,000 CalCOFI $100,000-$130,000	**Project #1: Blue And Fin Whale Satellite Tagging** *(Continuing)* **Project #2: Marine mammal sightings during CalCOFI cruises** *(Continuing)*
Further our understanding of the Monitoring Questions: *What, if any, are the short term behavioral and/or vocal responses when exposed to sonar or explosions at different levels or conditions?* *Does exposure to sonar or explosives impact the long term fitness and survival of individuals or the population, species or stock? (with focus on blue whale, fin whale, humpback whale, Cuvier's beaked whale, and other regional beaked whale species)*	• Determine what species and populations of marine mammals and ESA-listed species are present in U.S. Navy range complexes. • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where U.S. Navy training and testing activities occur. • Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where U.S. Navy training and testing activities occur. • Determine what behaviors can most effectively be assessed for potential response to U.S. Navy training and testing activities. • Develop and validate techniques and tools for detecting, classifying, and tracking marine mammals. • Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities. • Assess existing data sets which could be utilized to address the current objectives.	PAM, satellite tagging, Photo-ID, visual survey $200,000-$500,00	**Project #3: Fin and Cuvier's Beaked Whale Impact Assessment at the Southern California Offshore Antisubmarine Warfare Range (SOAR)** *(Continuing)* **Project #4: Blue, Fin, Humpback, and Cuvier's Beaked Whale Impact Assessment at Non-Instrumented Range Locations** *(Continuing)*
Further our understanding of the Monitoring Question: *What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training event?*	• Determine what species and populations of marine mammals and ESA-listed species are present in U.S. Navy range complexes. • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where U.S. Navy training and testing activities occur.	Lookout Effectiveness Study Protocol $40,000–$60,000	**Project 5: Navy Civilian Marine Mammal Observers On MFAS Ships In Offshore Waters of the Southern California Range Complex** *(Continuing)*

***** Anticipated Budget represents a projection; annual amounts subject to revision and conditional on final actual costs

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