MARINE SPECIES MONITORING
for the
U.S. Navy's
Hawaii Range Complex
and
Southern California Range Complex

Department Of The Navy

2011 ANNUAL REPORT

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MARINE SPECIES MONITORING
FOR THE
U.S. NAVY'S
HAWAII RANGE COMPLEX
AND
SOUTHERN CALIFORNIA RANGE COMPLEX

2011 ANNUAL REPORT

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EXECUTIVE SUMMARY

This report presents the U.S. Navy's Year Three level of effort, regulatory compliance, scientific accomplishments, and preliminary data obtained from marine mammal monitoring in the Hawaii Range Complex (HRC) and Southern California (SOCAL) Range Complex.

Year Three encompassed the period from 02 August 2010 to 01 August 2011. As outlined in the HRC and SOCAL Range Complex sections within this report, significant accomplishments were achieved from visual surveys; deployments of passive acoustic monitoring devices; marine mammal tagging, use of marine mammal observers; and leveraging of additional field efforts from several projects funded by multiple Department of the Navy organizations. Substantial data was collected, most of which is still undergoing analysis for use in a future 2012 or 2013 multi-year synthesis of results.

In general, the U.S. Navy met or exceeded its monitoring goals as stated in the Range Complex-specific Monitoring Plans modified through the 01 October 2010 HRC-SOCAL Monitoring Report to the National Marine Fisheries Service.

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LIST OF ACRONYMS

AMR	Adaptive Management Review
ASW	anti-submarine warfare
Bf	Beaufort
C2X	Composite Training Unit Exercise
CalCOFI	California Cooperative Oceanic Fisheries Investigation
CRC	Cascadia Research Collective
CREEM	Centre for Research into Ecological and Environmental Modelling
dB	decibel
DoN	Department of the Navy
EAR	Ecological Acoustic Recorder
EIS	environmental impact statement
ESA	Endangered Species Act
ft	feet
GPS	global positioning system
GUNEX	Gunnery Exercise, Surface-to-Surface
HARP	high-frequency acoustic recording package
HRC	Hawaii Range Complex
hrs	hours
IAC	Integrated Anti-submarine Warfare Course
ICMP	Integrated Comprehensive Monitoring Program
JTFEX	Joint Task Force Exercise
kHz	kilohertz
km	kilometer(s)
LOA	Letter of Authorization
m	meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MDSU	Mobile Diving and Salvage Unit-1
MFAS	mid-frequency active sonar
MISSILEX	Missile Exercise, Surface-to-Surface
MMC	Marine Mammal Commission
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
MMRC	Marine Mammal Research Consultants
MTE	Major Training Exercise
nm	nautical mile(s)
nm^2	square nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPAL	North Pacific Acoustics Laboratory
NUWC	Naval Undersea Warfare Center
OEIS	overseas environmental impact statement
ONR	Office of Naval Research
PAM	passive acoustic monitoring
PIFSC	Pacific Islands Fisheries Science Center
PMAP	Protective Measures Assessment Protocol
PMRF	Pacific Missile Range Facility
PTS	permanent threshold shift
R/V	research vessel
RHIB	Rigid hull inflatable boat
RIMPAC	Rim of the Pacific Exercise
SCC	Submarine Commanders Course
SES	Smultea Environmental Sciences
SINKEX	Sinking Exercise
SIO	Scripps Institution of Oceanography
SOAR	Southern California Offshore Anti-submarine warfare Range
SOCAL	Southern California
SSC PAC	Space and Naval Warfare Systems Center Pacific
SUSTEX	Sustainment Exercise
SWFSC	Southwest Fisheries Science Center
TTS	temporary threshold shift
UNDET	Underwater Detonation
USWEX	Undersea Warfare Exercise

INTRODUCTION

Background

The U.S. Navy developed Range Complex-specific Monitoring Plans to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973.

This report continues to provide range complex specific monitoring results for Year Three (02 August 2010 to 01 August 2011) within the Navy's Hawaii Range Complex (HRC) and Southern California (SOCAL) Range Complex.

The Range Complex Monitoring Plans were designed as a collection of focused "studies" to gather data that will attempt to address the following National Marine Fisheries Service (NMFS) questions which are described more fully in the previous NMFS' Letters of Authorizations (LOAs) and Navy Monitoring Plans:

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

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

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

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

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

Monitoring methods used for the Range Complex Monitoring Plans include a combination of research elements designed to support both Range Complex specific monitoring, and contribute information to a larger Navy-wide science-based program. The primary research elements include visual surveys from vessel or airplanes, passive acoustic monitoring (PAM), marine mammal observers (MMO), and marine mammal tagging. Each monitoring technique has advantages and disadvantages that vary temporally and spatially, as well as support one particular study objective better than another (e.g., DoN 2010a). The Navy uses a combination of techniques so that detection and observation of marine animals is maximized, and meaningful information can be derived to answer the research questions proposed above. Secondary techniques, such as photo-ID have been used on an increasing basis.

In addition to Fleet-funded Monitoring Plans described above, the Chief of Naval Operations Energy and Environmental Readiness Division (OPNAV N45) and the Office of Naval Research (ONR) have developed a coordinated Science & Technology and Research & Development program focused on marine mammals and sound. Total investment in this program has been greater than $150M over the past eight years. Several significant projects relative to Navy operational impact or lack of impact to marine mammals are currently funded and ongoing within the HRC and SOCAL Range Complexes. For example, in the SOCAL Range Complex, to leverage scientific expertise and funding availability, both U.S. Pacific Fleet and OPNAV N45 programs integrated certain elements of their programs to address the requirements as stated in the SOCAL Range Complex Monitoring Plan (see **Appendix A of SOCAL Range Complex section**).

Integrated Comprehensive Monitoring Program

The Integrated Comprehensive Monitoring Program (ICMP) provides the overarching framework for coordination of the U.S. Navy monitoring program (U.S. Navy 2010). It has been developed in direct response to Navy Range permitting requirements established in the various MMPA Final Rules, ESA Consultations, Biological Opinions, and applicable regulations. As a framework document, the ICMP applies by regulation to those activities on ranges and operating areas for which the Navy sought and received incidental take authorizations.

The ICMP is intended for use as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. Top priority will always be given to satisfying the mandated legal requirements across all ranges. Once legal requirements are met, any additional monitoring-related research will be planned and prioritized using guidelines provided by the ICMP, consistent with availability of both funding and scientific resources. As a planning tool, the ICMP is a "living document." It will be routinely updated as the program matures. Initial areas of focus for maturing the document in 2010/2011 included further refinement of monitoring goals, adding a characterization of the unique attributes associated with each range complex / study area to aid in shaping future monitoring projects, as well as a broader description of the data management organization and access procedures.

The ICMP is evaluated annually through the Adaptive Management Review (AMR) process to: (1) assess progress, (2) provide a matrix of goals 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 Navy and NMFS jointly consider the prior year goals, monitoring results, and related science advances to determine if modifications are needed to more effectively address monitoring program goals. Modifications to the ICMP that result from AMR discussions are incorporated by an addendum or revision to the ICMP. Official ICMP updates are provided to NMFS by 31 December annually (e.g., U.S. Navy 2010).

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

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

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

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

(d) An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either: 1) the long-term fitness and survival of an individual; or 2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival).

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

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

OPNAV (N45) is responsible for maintaining and updating the ICMP, as necessary, reflecting the results of future regulatory agency rulemaking, AMRs, best available science, improved assessment methodologies, and more effective protective measures. This is done in consultation with Navy technical experts, Fleet Commanders, and Echelon II Commands as appropriate, and as part of the AMR process.

Report Objectives

Design of the Range Complex Monitoring Plans represented part of a new Navy-wide assessment, and as with any new program, there are many coordinating, logistic, and technical details that continue to be refined. The scope of the original 2008 Range Complex Monitoring Plans was to discuss the background for monitoring as well as define initial procedures to be used in meeting study objectives derived from the NMFS-Navy agreements. Monitoring results are presented each year to the NMFS and the next year's monitoring goals established based on the adaptive management process.

Overall, and in support of the above statement, this report has two main objectives:

1. Present data and results from the Navy-funded marine mammal and sea turtle monitoring conducted in the HRC and SOCAL Range Complex from 02 August 2010 to 01 August 2011.

Included in this assessment are reportable metrics of monitoring as requested by the NMFS. This Year Three report will focus mostly on summarizing collected data and providing a brief description of the major accomplishments from techniques used this year, while referring to the more technical discussions in various Appendices provided by the scientists who performed the monitoring work on the two Range Complexes.

2. Continue the adaptive management process by providing an overview of meetings and initiatives over the past year that support proposed revisions to the Navy's 2012 SOCAL Range Complex and HRC Monitoring Plans as well as presenting progress made towards development of a Strategic Plan for Navy Monitoring that has been facilitated by establishing a Scientific Advisory Group to review and provide recommendations on the Navy's monitoring program. Proposed changes primarily reflect input received from the scientific community and other stake holders. An overview of the events that have prompted these most recent adaptive management actions is provided in the following sections.

HAWAII RANGE COMPLEX

Monitoring in the Hawaii Range Complex

This section reports accomplishments from the Navy's marine species field monitoring efforts in the HRC. The HRC consists of 235,000 square nautical miles (nm^2) of surface and subsurface ocean areas and special use airspace for military training and research, development, testing and evaluation (RDT&E) activities. The HRC includes the Pacific Missile Range Facility (PMRF) on Kauai which is both a Fleet training range and a Fleet and Department of Defense (DoD) RDT&E range. The PMRF includes an instrumented range covering 1,020 nm^2 of ocean area at depths between 1,800 feet (ft) and 15,000 ft. Various subcomponents of the range complex are more fully described in the *Hawaii Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement* (HRC EIS/OEIS; DoN 2008). Monitoring efforts are divided into two major categories – those field efforts implemented by the U.S Pacific Fleet as part of the HRC compliance monitoring, and those funded by the ONR and the Chief of Naval Operations Environmental Readiness Division. Reporting will primarily focus on the U.S. Pacific Fleet's compliance monitoring required under the Fleet's MMPA permit (LOA) and ESA consultation; however, highlights from the Navy's research monitoring are presented in Part III of this Section.

In the HRC Monitoring Plan, the Navy proposed to implement a diversity of field methods to gather field data from marine mammals and sea turtles in conjunction with training events. Studies were specifically designed to meet the questions outlined in the Introduction section of this document. Metrics (e.g., hours or events) were agreed to by the Navy and the NMFS and used as a goal for implementation.

During Study Year Three (02 August 2010 to 01 August 2011), U.S. Pacific Fleet implemented aerial and vessel surveys; embarked MMOs on Navy platforms; tagged a variety of cetaceans and pinnipeds; and deployed PAM devices. This work builds upon U.S. Pacific Fleet-funded fieldwork that has occurred in the Hawaiian Islands since the Rim of the Pacific (RIMPAC) Exercise in 2006.

HRC YEAR THREE (02 AUG 2010 TO 01 AUGUST 2011) MONITORING OBJECTIVES

The goal of the HRC Monitoring Plan as revised (DoN 2010a) is to implement field methods chosen to address the long-term monitoring objectives outlined in the Introduction. **Table H-1** from the final HRC Monitoring Plan shows the FY 2011 monitoring objectives agreed upon by the NMFS and the Navy.

The U.S. Pacific Fleet began conducting aerial and vessel surveys in conjunction with major exercises in 2006. Most aerial and vessel surveys from 2006 to 2008 were conducted only before and after, however, some vessel surveys were conducted during the event as well. These early surveys not only provided data points that will be used in future analysis, but they also provided proof-of-concept data for determining the feasibility of using diverse field methods in the HRC. Based upon lessons learned from those surveys and input from the NMFS, the Navy shaped the studies in the HRC Monitoring Plan with proven field methods that would provide visual and acoustic data to support scientific assessment on the potential effects from Navy training on marine species.

In the HRC Monitoring Plan, the Navy commited to use visual surveys (aerial and vessel) and marine mammal observers aboard Navy vessels during anti-submarine warfare (ASW) and explosive events to meet its goals. Navy also proposed to deploy and analyze data from passive acostic monitoring devices in 2010 and to purchase and deploy tagging devices.

Table H-1. Year Three monitoring commitments for the Hawaii Range Complex (DoN 2010a).

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) STUDIES 1, 2, 3, 4, 5	120-160 hours before, during and after anti-submarine warfare (ASW) and/or explosives training events	Adaptive Management Review (AMR) for FY12
Marine Mammal Observers (MMO) STUDIES 1, 2, 3, 4, 5	MMO team aboard Navy surface platforms during 2 ASW and 6 explosive events	
Tagging STUDIES 1, 2, 3	Tag a goal of 15 individual marine mammals	
Passive Acoustic Monitoring (PAM) STUDIES 1, 2, 3	• 4 PAM devices deployed through the year. Begin data analysis. Continue collaboration of data collection and analysis from additional N45/ONR-funded autonomous PAM devices. • Continue use of the Pacific Missile Research Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.	

HAWAII YEAR THREE MAJOR TRAINING EXERCISE SUMMARY

Given the focus on monitoring around Navy at-sea training events, a list of major training events (MTEs), which occurred in the HRC between 02 August 2010 and 01 August 2011, is provided in **Table H-2**. Marine mammal sightings during MTEs are a form of compliance monitoring and represent substantial numbers of sightings. For the HRC, MTEs may include RIMPAC exercises, Undersea Warfare Exercises (USWEX), and Multi Strike Group Exercises.

Table H-2. Hawaii Range Complex major training events from 02 August 2010 to 01 August 2011.

MTE Type	Dates	# of Days	# of Ships Involved	# of Sea Turtle Sightings	# of Sea Turtles	# of Marine Mammal Sightings	# of Marine Mammals
Koa Kai	12-17 Nov 2010	5	5	0	0	10*	41
USWEX	15-22 Feb 2011	8	6	0	0	19*	46
Totals:		**13**	**11**	**0**	**0**	**29**	**87**

* One acoustic detection with no visual sighting

There were two MTEs in the HRC between 2 August 2010 and 1 August 2011 – one Koa Kai (similar in composition to a USWEX) and one USWEX. During transits and training events during those MTEs, Navy lookouts reported 29 marine mammal sightings for an estimated 87 marine mammals (**Table H-3**). There were 4 marine mammal sightings reported at a range less than 1000 yards (914 meters [m]) concurrent with mid-frequency active sonar (MFAS) use (**Table H-4**).

Table H-3. Total number of marine mammal and sea turtle sightings observed from Navy platforms during Hawaii Range Complex major training events from 02 August 2010 to 01 August 2011.

Species Type	# of sightings	% of total sightings	# of sea turtles or marine mammals	% of total number of sea turtles or marine mammals
Dolphins	4	13	36	43
Whales	22	71	43	51
Pinnipeds	0	0	0	0
Sea Turtles	0	0	0	0
Species not reported	5	16	5	6
Totals:	**31**	**100**	**84**	**100**

Table H-4. Number of marine mammal sightings at ranges less than 1,000 yards observed from Navy platforms during major training events concurrent with MFAS mitigation from 02 August 2010 to 01 August 2011 in the Hawaii Range Complex.

Mitigation Range	# of Sightings	Total Number of Marine Mammals	Breakdown by Species Type		
			# of Dolphins	# of Whales	# of Sea Turtles
< 200 yards	0	0	0	0	0
200-500 yards	1	1	0	1	0
500-1000 yards	3	32	30	2	0
Totals:	**4**	**33**	**30**	**3**	**0**

* Note that many mitigation ranges were not reported by the ships, so these numbers may be an under-representation of the totals in each category.

Ranges associated with potential NMFS criteria levels of permanent threshold shift (PTS) and temporary threshold shift (TTS) (215 and 195 dB re 1 μPa2-s, respectively) are much shorter than 200 yards (183 m). During the HRC MTEs this reporting period, there were no reported sightings of marine mammals or sea turtles at less than 200 yards (183 m) concurrent with MFAS use.

The three categories of mitigation measures (Personnel Training, Lookout and Watchstander Responsibilities, and Operating Procedures) outlined in the HRC EIS/OEIS (DoN 2008) and approved by the NMFS (NMFS 2010, 2011) were effective in detecting and appropriately mitigating exposures of marine mammals to MFAS. Fleet commanders and ship watch teams continue to improve individual awareness and enhance reporting practices. Additionally, a lookout effectiveness study was conducted by the Navy and provided data to demonstrate the effectiveness of the Navy's suite of mitigation measures.

HAWAII YEAR THREE MONITORING ACCOMPLISHMENTS

Marine species monitoring in conjunction with training events has been funded by U.S. Pacific Fleet since 2006. From 2006-2008, surveys focused on visual line transect surveys conducted before and after training events, collecting visual sighting data, photographs, video and behavioral observations. Aerial and vessel surveys were conducted during RIMPAC 2006 (Mobley 2006), USWEX (Cetos 2007, Mobley 2007, Mobley 2008a,b), and RIMPAC 2008 (Mobley 2008c, Smultea and Mobley 2008).

Monitoring during 2009 and 2010 expanded after the finalization of the HRC Monitoring Plan in early 2009. Novel approaches for conducting aerial surveys in close proximity to Navy training events were successfully implemented in 2009 and 2010, providing valuable behavioral observations while ASW was occurring. Additionally, data was collected by embarking marine mammal observers on Navy platforms; tagging Hawaiian monk seals; deploying PAM devices; and conducting aerial and vessel visual surveys (see DoN 2009, 2010b).

During 2011, U.S. Pacific Fleet implemented aerial and vessel surveys; embarked MMOs on Navy platforms; tagged pinnipeds and a variety of cetaceans; and deployed PAM devices. **Table H-5** presents a summary of Navy funded marine mammal monitoring within the HRC during Year Three.

Major Accomplishments from U.S. Pacific Fleet's Year Three Compliance Monitoring in the HRC:

- Visual (Vessel) Survey
  - A small vessel survey during November 11-23, 2010, covered an area of approximately 8,000 nm², in an area 80 nm south of Oahu, and 60 nm west of the Big Island (Hawaii). Marine species monitoring occurred before, during, and after the Koa Kai (a USWEX) 11-1 training event. The survey's purpose included investigating the occurrence, distribution, and behavior of target species (marine mammals and sea turtles) using vessel-based line-transect survey in waters adjacent to the area where the Navy exercise was occuring. See **Appendix B**: HDR EOC 2011.
  - A small vessel survey using the *M/V Searcher* was conducted during February 16-20, 2011 to Ka'ula and off the north shore of Kauai during and after SCC 11-1 which took place on the PMRF near Kauai. The primary goals of the survey were to study the presence of marine mammals, including Hawaiian monk seals, at Ka'ula, as well as to deploy satellite tags in order to contribute knowledge regarding how odontocetes are using the range complex and whether they are exposed to MFAS (see *Tagging accomplishments* section). Additionally, sightings of seabirds and marine mammals were recorded (no sea turtles were sighted). See **Appendix C**: Richie and Fujimoto 2011.
  - A small vessel survey was conducted on June 30, 2011 using the *M/V Searcher* to record sightings of seabirds and marine mammals offshore of Ka'ula Island and in the waters between Niihau and Kauai, including the PMRF areas W-186 and W-187. Objectives were to: (1) obtain cetacean dorsal fin photographs for individual identification purposes; (2) deploy a PAM device offshore to the east of the island; and (3) examine the NW shore of the island where Hawaiian monk seals had been sighted. A total of six marine mammal groups were sighted; three groups of bottlenose dolphins, one group of rough-toothed dolphins; one group of spinner dolphins, and two hauled-out Hawaiian monk seals on a short stretch of shoreline. No sea turtles were sighted. See **Appendix D**: Uyeyama et al. , 2011.
  - A small vessel survey during 20 July-8 August was cooperatively funded with the Naval Postgraduate School and N45, and was conducted by Cascadia Research Collective on and near the instrumented range at PMRF offshore Kauai in conjunction with the July SCC. The primary goals were to validate species identifications of acoustic detections by the M3R hydrophone array, as well as to deploy satellite tags in order to contribute knowledge regarding how odontocetes are using the range complex and whether they are exposed to MFAS (see *Tagging accomplishments* section).
- Visual (Aerial) Survey
  - Aerial surveys of the shorelines of the Hawaiian Islands and islets within the vicinity of the November 2010 Koa Kai-11 training event were performed on November 18 and 22, 2010. The objective of the aerial-based monitoring was to conduct coastline and pelagic surveys during and after training events in search of otherwise-undetected strandings. See **Appendix B**: HDR EOC 2011.

- Aerial surveys were conducted in conjunction with two training events during the period February 16 to March 5, 2011: (a) U.S. Navy Submarine Commander's Course (SCC) 11-1 naval training event on the PMRF instrumented range between Kauai and Niihau, Hawaii; and (b) Undersea Warfare Exercise (USWEX) training event south of Oahu and Molokai (**Appendix E**: Mobley 2011). These surveys also coincided with the Ka'ula vessel survey (see *Vessel Survey accomplishments* above) and the Marine Mammal Observers embarked upon a participating U.S. Navy Destroyer (see *Marine mammal observers accomplishments* below). Overall survey effort was divided into four parts as summarized below:
  - Ship follows, SCC event (February 16–18, 2011): involved flying elliptical orbits in front of the guided-missile destroyer (DDG) with the goal of finding target species in the vicinity of the DDG and observing and recording their behavior using focal follow methods.
  - Tagging-support transect surveys (February 19, 2011): to search for marine mammals in support of tagging effort by the Cascadia research group and Ka'ula vessel survey. This effort continued to demonstrate that during certain training events, contracted civilian aircraft may be used as a method for conducting behavioral monitoring of submerged and at-surface marine mammals.
  - Coastline surveys, post-SCC event (February 24 and 26, 2011): following the SCC event, the aircraft flew along the coastlines of Kauai, Niihau, and Ka'ula islands in search of otherwise-undetected marine mammal strandings.
  - Coastline surveys, post-USWEX event (February 28 and March 5, 2011): following the USWEX training event, the aircraft flew along the coastlines of Oahu, the Four Island Region (Maui, Molokai, Lanai, and Kahoolawe), and the Kona coast of the island of Hawaii.

- Passive Acoustic Monitoring
  - Four PAM devices were deployed in areas of the HRC where underwater detonations or anti-submarine warfare exercises may occur nearby.
  - As part of the June 30, 2011 monitoring effort off Ka'ula (see Visual (Vessel) Surveys above), an Ecological Acoustic Recorder (EAR) was deployed at a depth of 537 m east of Ka'ula Island. See **Appendix D**: Uyeyama et al. 2011. Three other EARs were deployed July 26, 2011 nearby, offshore the North, Southwest, and Eastern shores of Niihau at approximately 800 m.
  - Analysis of marine mammal acoustic data collected during FY10. An EAR deployed on July 17, 2010 (during marine species monitoring associated with RIMPAC 2010) at a depth of 800 m off the northwest coast of the island of Ni'ihau was recovered on December 21, 2010 (it had ceased recording on October 22). Beaked whales were detected daily. Most (approximately 87 percent) of the detections occurred at night, which is likely a reflection of the behavior of beaked whales responding to prey movements. Other species detected included the pilot whale, Risso's dolphin, sperm whale, and dolphins in the genus *Stenella*. Pilot whales had the highest number of detections, while beaked whales had the least number of detections. Of note was that the Risso's dolphin was the second most-detected toothed whale

species, while not consistently sighted in Hawaiian waters. See **Appendix F:** HDR/EOC and Au 2011.

- Marine Mammal Observers (MMO)
  - Three ASW training events were monitored: Koa Kai, SCC, and USWEX.
    - A four-person observer team (three Navy civilian MMO and one Navy contractor MMO) conducted the lookout effectiveness study duringthree ASW training events in the Hawaii Range Complex, Koa Kai 11-1 from 12-16 November 2010 (see **Appendix G**: Farak et al. 2011a), and two consecutive events, SCC and USWEX from from 15-22 February, 2011 (see **Appendix H**: Farak et al. 2011b). These MMOs were stationed aboard a U.S. Navy cruiser (CG-A) for Koa Kai, and a U.S. Navy destroyer (DDG-D) for SCC and USWEX. In addition to collection of lookout sighting data, detailed sighting data was collected including species identification, surfacings, and behavior.
    - Four explosive events (underwater detonations: UNDETs) were monitored: Two UNDETs each day during the 26-27 April training event conducted by Mobile Dive and Salvage Unit-1 (MDSU-1) in the Pu‘uloa Underwater Training Range. MMOs observed for marine mammals and sea turtles as well as implementation of mitigation measures (**Appendix I**: Uyeyama and Richie 2011).
- Tagging
  - From February 16-20, 2011, CRC conducted research off the island of Kauai (see *Vessel Survey accomplishments* section) (See **Appendix J**: Baird et al. 2011; **Appendix D:** Richie and Fujimoto 2011). The three goals were: (1) photo-identification; (2) biopsy sampling; and (3) tagging to examine habitat use and movement patterns. *The R/V Searcher* and a rigid-hulled inflatable boat (RHIB) were used. Three individual short-finned pilot whales were satellite-tagged. Overall ranging patterns of the whales differed, with one individual moving to Oahu and back, while another moved further west.
  - Ten Hawaiian monk seals were instrumented with “cell phone” tags on Oahu, Kauai and Molokai continuing effort that began with eleven animals tagged in 2010. Of those tags, tracks were obtained from 13 animals – some are still deployed. Data are currently being analyzed to identify home ranges and core areas of use. (**Appendix M:** Wilson and Littnan, 2011.)
- Integration of historical monitoring data
  - The total of visual survey effort conducted for the marine species monitoring program in the HRC was integrated and summed as part of the initial phase of analyzing all years of the monitoring program. Aerial and vessel surveys on civilian and Navy assets from 2007-2011 were included, and the data incorporated into a geo-referenced database. Results included figures representing the layered sum of all survey tracklines as well as sightings by species. See **Appendix L:** Uyeyama 2011.

- **Navy Lookout Effectiveness Study**

The U.S. Navy undertakes monitoring of marine mammals during Navy exercises and has mitigation procedures designed to minimize risk to these animals. One key component of this monitoring and mitigation is the shipboard lookouts (LOs, also known as watchstanders), who are part of the standard operating procedure that ships use to detect objects (including marine mammals) within a specific area around the ship during events. The watchstanders are an element of monitoring requirements specified by NMFS in the MMPA Letters of Authorization. The goal is to detect mammals entering ranges of 200, 500 and 1000 yards around the vessel, which correspond to distances at which various mitigation actions should be performed. In addition to the lookouts, officers on the bridge search visually and SONAR operators listen for vocalizations during anti-submarine warfare training. We refer to all of these observers together as the "observation team" (OT). The aim of this study is to determine the OT effectiveness in terms of detecting and identifying marine mammals. Of particular interest is the probability of an animal getting within a defined range of the vessel without being observed by the OT, as well as determining the accuracy of the OT (primarily the LO) in determining species group (whale, dolphin, etc.) group size and position. In order to achieve this, experienced MMOs search and collect information on marine mammals that both they and the OT detect.

Work was previously conducted to design and test a protocol for determining the effectiveness of the LOs in visually detecting marine mammals. The field protocol for the experiments was developed in consultation with members of the Naval Undersea Warfare Center Division, Newport (NUWCDIVNPT); U.S. Fleet Forces Command; NAVFAC; Commander, U.S. Pacific Fleet; and NMFS. The basic concept is that trained Marine Mammal Observers (MMOs) are situated on board a vessel during daylight at-sea exercises, in locations where they can watch for marine mammals and communicate with one another, but not cue the LO. The MMOs then work to set up opportunistic trials, where they detect a surfacing of a marine mammal at a measured location, and record whether that surfacing was also detected (a successful trial) or not (an unsuccessful trial) by the LO.

It was found to be necessary to have an additional "liaison" MMO (LMMO) stationed with the LO, and in communication with the other MMOs, to help report when and where LOs detected surfacings. It was also necessary to have an additional team member tasked solely with data recording. In addition to recording surfacing events, MMOs attempted to keep track of which surfacings belonged to the same school or animals. The revised protocol (Burt and Thomas 2010) was applied to one further at-sea exercise (off Southern California), making four datasets in total.

In parallel with field protocol development, methods are being developed for using the data generated during these experiments to estimate the probability of animals entering the stand-off range undetected. An analysis method to allow for intermittent availability is also being developed, since many marine mammal species remain on (or close to) the surface for significant periods between dives, and so are "intermittently available" for detection. The extended methods currently only use information about the location of LO detections, but could conceivably be extended further to use information from the MMO LO trials. As a proof of concept both the instantaneous and intermittent availability models to data collected in the at-sea experiments will be applied.

Recommendations for future data collection efforts focus on a single vessel type and an area where the number of trials per cruise is likely to be maximized. Resources would be devoted to extending the intermittent availability models so that they use both the locations of observed animals and the outcomes of the MMO trials, thereby unifying the models developed to date for instantaneous and intermittent availability.

Major accomplishments related to this project to date include initial development of data collection protocols and analytic methods, data collection trials, completed a proof of concept for detection functions, consultation with NMFS technical staff for input on analysis methods, and investment in continued refinement of the analytic methods and focus on additional data collection in 2011/2012.

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

- **Use of Instrumented Underwater Range Phones for PAM at Pacific Missile Range Facility**

  Analysis was conducted for a focused period during the February 2011 Submarine Commanders Course exercise (SCC) at Pacific Missile Range Facility (PMRF) (Marint and Kok, **Appendix N**). The focus period is between 05:58 and 07:39 HST on 17 February 2011 corresponds with a visual sighting made by marine mammal observers aboard the transmitting ship. This period covers mid frequency active sonar (MFAS) activity in the event termed miniwar III which involved one submarine participant, a U.S. Navy destroyer (DDG) equipped with the AN/SQS-53C sonar system, and two additional surface ships with other sonar systems. This focus period represents the first exposure analysis at PMRF for marine mammals during a SCC. Analysis is ongoing for other detections.

  Animal locations were obtained both from a visual sighting for a small group of unidentified whales and processing of passive acoustic data for one minke whale and one humpback whale. Positions, and estimated headings, of the DDG were obtained from PMRF exercise products. Full report (Appendix N) provides additional details of the exposure analysis, such as the equations used for the calculations, along with more in depth passive acoustic analysis for minke and beaked whales.

  The use of passive acoustics for monitoring during U.S. Navy training with MFAS activity shows promise in estimating exposure levels during exercises on instrumented ranges and can provide position data better than tags. Repeated localizations, such as the minke whale in this case, allows investigation of both spatial updates of the animals location with respect to the MFAS ship (swim speed, direction of travel) and details of the animals calls with MFAS activity nearby in space and time (e.g. call rates, types of calls, differences in call characteristics re. MFAS activity).

Table H-5. U.S. Navy-funded marine mammal monitoring accomplishments within the Hawaii Range Complex from 02 August 2010 to 01 August 2011.

Study Type	U.S. Navy EIS/LOA monitoring	Associated event type	U.S. Navy R&D funded monitoring	Associated event type	MMPA/ESA requirement	Total accomplished
Visual surveys (Studies 1,2,3,4,5)	1) 95.2 hrs – 11-23 Nov 2010 (vessel) 2) 14.1 hrs – 18-22 Nov 2010 (aerial) 3) 46.1 hrs – 16 Feb – 5 Mar 2011 (aerial) 4) 60.2 hrs 15-20 Feb (vessel) 5) 11.5 hrs Ka'ula survey 30 June 6) 72.7 hrs PMRF pre-SCC July/Aug (vessel)	1) Koa Kai (ASW) 2) Koa Kai (ASW) 3) SCC & USWEX (ASW) 4) SCC (ASW) 5) n/a 6) SCC (ASW)	Use of M3R array at PMRF for validation of species ID, animal localization February (baseline and during SCC) and July 2011.	SCC	120- 160 hours before, during and after ASW and/or explosives training events	299.8 hours of aerial and vessel surveys
Marine Mammal Observers (Studies 1,2,3,4,5)	1) 140.5 hrs - 12-17 Nov 2010 2) 118.0 hrs - 15-18 Feb 2011 3) 124.0 hrs - 19-22 Feb 2011 4) 11 hrs - 26-27 Apr 2011	1) Koa Kai (ASW) 2) SCC (ASW) 3) USWEX (ASW) 4) Underwater detonations	n/a	n/a	MMO team aboard Navy surface platforms during 2 ASW and 6 explosive events. (make up for FY10 shortfall of 1 ASW event)	3 ASW events and 4 explosive events. (Note: extra ASW event covers shortfall from next year.) *Note: Lookout effectiveness for 2 explosive events with MDSU-1 originally planned for July 2011 rescheduled and accomplished 10 Aug 2011*
Tagging (Studies 1,2, 3)	1) 10 Hawaiian monk seals tagged 2) 3 cetaceans tagged (pre-SCC Cascadia Research Collective effort off Kauai; 16-20 Feb) 3) 2 tag deployed in conjunction with M3R Jul -Aug 2011 (one successful)	1) ULT (ASW) 2) SCC (ASW) 3) USWEX (ASW)	Use of M3R array at PMRF for validation of species ID, animal localization February (baseline and during SCC) and July 2011.	SCC	Tag a goal of 15 individual marine mammals (make up for FY10 shortfall of 4 tags)	10 Hawaiian monk seals tagged); 4 cetaceans tagged (additional one deployed but fell off) Continuing analyses of tag data from FY 10 monitoring

Study Type	U.S. Navy EIS/LOA monitoring	Associated event type	U.S. Navy R&D funded monitoring	Associated event type	MMPA/ESA requirement	Total accomplished
Passive Acoustic Monitoring (Studies 1, 2, 3)	1) 1 EAR deployed at Ka'ula; 30 June 2) 3 EAR deployments in vicinity of Kauai and Niihau, 26 July 3) Continue use of PMRF hydrophones to gather and analyze marine mammal acoustic data in conjunction w/ SCC.	SCC (ASW)	Use of M3R array at PMRF for validation of species ID, animal localization February (baseline and during SCC) and July 2011.	SCC	4 PAM devices deployed through the year. Begin data analysis. Continue collaboration of data collection and analysis from additional N45/ONR-funded autonomous PAM devices. Continue use of the Pacific Missile Range Facility (PMRF) instrumented range hydrophones to gather and analyze marine mammal acoustic data.	Deployment of 1 EAR near Ka'ula ; Deployment of 3 EARS near Kauai/Niihau Analysis of 2 EARS from near Niihau, 4 near Oahu (historical) and 2 near Kauai (historical) Use of PMRF hydrophones to gather and analyze marine mammal acoustic data in conjunction w/ SCC.

Metrics Met or Exceeded

Visual Surveys: Over 213 hours of visual surveys (vessel and aircraft platforms) were conducted in conjunction with trainin events . This exceeded by more than 50 percent, the 120-160 hours of survey effort before, during, and after ASW and/or explosive events commited to in the HRC monitoring plan covering the period of 02 August thru 01 August 2011.

Marine Mammal Observers: The HRC Monitoring Plan for FY 2011 and the HRC LOA for 2011 calls for an MMO team aboard Navy surface platforms during 2 ASW events. An MMO team embarked during 3 ASW events, the extra event compensating for the shortfall of 1 ASW event in FY 2010.

Tagging: Fifteen individual marine mammals were tagged from 02 August thru 01 August 2011.

Metric Shortfalls

Marine Mammal Observers: The HRC Monitoring Plan for FY 2011 and the HRC LOA for 2011 calls for an MMO team aboard Navy surface platforms during 6 explosive events. Due to an event cancellation, MMO teams embarked during only 4 underwater detonations by the July 31 cutoff, for a shortfall of 2. These two additional events were monitored by an MMO team a few weeks later on August 10, 2011. Therefore this shortfall will be satisfied by the August 10 effort when these events are tabulated for FY12.

Tagging: The Navy's goal was to tag a total of 19 marine mammals, 15 from the FY11 goals, as well as to compensate for a shortfall of 4 tags from FY10. However 15 tags were expended on attempted deployments, 14 successfully, therefore considering the shortfall from FY10, there was an overall shortfall of 4 tags in FY11. The 15 tags for FY11 include: 10 cell phone tags deployed on Hawaiian monk seals by NMFS, and 5 satellite tags (4 successful deployments) by Cascadia Research Collective on two separate field efforts in February and July 2011. The latter effort by CRC encountered unusually difficult summer weather conditions, and despite being vectored to animals by the M3R hydrophone array, more tags were not deployed by the July 31 deadline. However, CRC successfully deployed two additional tags after the deadline durng the same field effort, and these will be counted towards FY12 monitoring accomplishments.

OTHER NAVY-FUNDED RESEARCH IN HAWAII

There were also additional marine protected species research efforts within the HRC that were funded by OPNAV N45 and ONR. ONR funded several projects in the HRC that are related to the U.S. Pacific Fleet's monitoring goals which are summarized below.

1) *Passive Acoustic Methods/Tracking* (Eva Nosal, Dept. of Ocean & Resources Engineering, University of Hawaii). Funded in part by ONR.

   Passive Acoustic Methods for Tracking Marine Mammals Using Widely-Spaced Bottom-Mounted Hydrophones. (ONR Award N000140811142). The main objective of this project is to develop and implement methods to deal with two specific challenges associated with tracking marine mammals using widely-spaced bottom-mounted hydrophone arrays: (1) Multiple animals whose calls cannot be easily separated or associated, and (2) Insufficient receiver coverage, in which case standard time-of-arrival (TOA) tracking methods fail. The main effort is directed toward data collected at Navy Ranges (PMRF and AUTEC). The main species of interest in these datasets are sperm whales, beaked whales, minke whales, and humpback whales. *Ecological Acoustic Recorders* (Whitlow Au and Marc Lammers, Hawaii Institute of Marine Biology), Funded by ONR

   EARs have been deployed from February 2009 to the present time around Oahu and from February 2009 until April 2011 around Kauai. The effort at Kauai has concentrated on deep-diving beaked whales. Since April 2011, EARs in the waters of Kauai have been deployed along the southern coast. With funding support from Pacific Fleet, acoustic data recorded by EARs deployed at various locations around Oahu and Kauai were analyzed for various type of sounds including ambient noise, boat sounds, mid-frequency sonar emissions, dolphins and whales. See **Appendix K**.

   The project received an M3R node in late August 2010which is currently being used to process the data from Kauai and for the EAR off Barbers Point, Oahu, which is at a depth of 581 m. The M3R system is designed to detect both Blainville's and Cuvier's beaked whales. Eventually all the EAR data will be analyzed with the M3R node. *Hearing and Echolocation of Odontocetes* (Paul Nachtigall et al., Hawaii Institute of Marine Biology), Funded by ONR.

   Paul Nachtigall's team of researchers and students published results on the audiogram of a sub-adult Blainville's beaked whale that stranded on the island of Maui in August 2010, The team also worked to build a rugged field-ready portable battery-operated system to use to measure the hearing capabilities of marine mammals in the lab, on ships, on the beach or wherever the opportunity arises. Additional work included finalized publications on dolphin hearing during echolocation (which was referred to in the 2010 HRC monitoring report).

   Related publications: Kloepper et al. 2010; Li et al. 2011; Pacini et al. 2011.

HRC ADAPTIVE MANAGEMENT AND 2012 MONITORING PLAN

Adaptive management is an iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. Within the natural resource management community, adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable ecosystems. Adaptive management helps science managers maintain flexibility in their decisions, knowing that uncertainties exist and provides managers the latitude to change direction will improve understanding of ecological systems to achieve management objectives; and is about taking action to improve progress towards desired outcomes.

A 2010 Navy-sponsored monitoring meeting in Arlington, VA initiated a process to critically evaluate the current Navy monitoring plans and begin development of revisions/updates to both existing region-specific plans as well as the Integrated Comprehensive Monitoring Program (ICMP). Discussions at that meeting as well as the following Navy/NMFS annual adaptive management meeting (Oct 2010) established a way ahead for continued refinement of the Navy's monitoring program. This process included establishing a Scientific Advisory Group (SAG) of leading marine mammal scientists with the initial task of developing recommendations that would serve as the basis for a Strategic Plan for Navy monitoring. The Strategic Plan is intended to be a primary component of the ICMP and provide a "vision" for navy monitoring across geographic regions - serving as guidance for determining how to most efficiently and effectively invest the marine species monitoring resources to address ICMP top-level goals and satisfy MMPA Letter of Authorization regulatory requirements. The objective of the Strategic Plan is to continue the evolution of Navy marine species monitoring towards a single integrated program, incorporating SAG recommendations, and establishing a more transparent framework for soliciting, evaluation, and implementing monitoring work across the Fleet range complexes. The Strategic Plan is currently being developed in coordination with NMFS HQ and Marine Mammal Commission (MMC) input and will establish the process for soliciting, reviewing, and selecting the most appropriate monitoring projects to invest in across the Navy. It is anticipated that some current efforts will continue but the level of effort and investment may be allocated differently across Navy Ranges.

Originally, five study questions were developed between NMFS and the Navy as guidance for developing monitoring plans (as presented in the Introduction), and all existing range-specific monitoring plans attempted to address each of these study questions. However, the state of knowledge for the various range complexes is not equal, and many factors including level of existing information, amount of training activity, accessibility, and available logistics resources, all contribute to the ability to perform particular monitoring activities. In addition, the Navy monitoring program has historically been compartmentalized by range-complex and focused on effort-based metrics (survey days, trackline covered, etc.).

Navy established the SAG in 2011 with the initial task of evaluating current Navy monitoring approaches under the ICMP and existing LOA's to develop objective scientific recommendations that would form the basis for the Strategic Plan. While recommendations were fairly broad and not prescriptive from a range complex perspective, the SAG did provide specific programmatic recommendations that serve as guiding principles for the continued evolution of the Navy Marine Species Monitoring Program and provide a direction for the Strategic Plan development. The meeting resulted in refinement of the five study questions of the ICMP into six study goals, as earlier described in detail in the Background section of the Introduction of this report. The SAG also provided three general recommendations that apply broadly across the Navy's monitoring program:

- Transparency, collaboration, and data accessibility;
- Specific Programmatic recommendations in four key areas: (1) overall monitoring objectives and scope; (2) operational methodology; (3) data analysis and integration; and (4) procedural logistics.
- The importance of monitoring the effects of all types of training exercises, including low-frequency active sonar and explosives.

Specific to the HRC, the SAG recommended a broad suite of monitoring for this area including passive acoustic monitoring, and non-systematic surveys incorporating biopsy, tagging and photo-identification studies. It was noted that the fixed hydrophone array off Kauai allows for acoustic monitoring and would provide potential synergy with boat-based monitoring efforts. In June 2011, the Navy hosted a Marine Mammal Monitoring Workshop with guidance and support from NMFS that included scientific experts and representatives of environmental non-governmental organizations (NGOs). The purpose of the workshop was to present a consolidated overview of monitoring activities accomplished in 2009 and 2010 pursuant to the Final Rules currently in place, including the SAG review, outcomes of selected monitoring-related research and lessons learned, and to seek feedback on future directions. A significant outcome of this workshop was to continue consolidating monitoring efforts from individual range complex plans and develop a single Strategic Plan for Navy Monitoring that will improve the return on investment by focusing specific objectives and projects where they can most efficiently and effectively be addressed throughout the Navy range complexes. The Strategic Plan is currently in development and will be incorporated as a primary component of the ICMP.

Results of recent meetings, recommendations from the SAG as well as success and challenges in the field are under review and will be further discussed with NMFS at the annual adaptive management meeting in October 2011. Results will be used to revise and improve the monitoring progam in the coming years, while maintaining the same level of effort. Therefore, other than adding more flexible language to the PAM section, no changes are being recommended for the 2012-2014 LOA Renewal period at this time (see **Table H-6**). Once review of current monitoring methods and metrics are completed, they will be incorporated into revised monitoring plans.

Table H-6. 2012-2014 Monitoring Commitments

<table>
<tr><th>Monitoring Technique</th><th colspan="2">Implementation</th></tr>
<tr><td>Visual Surveys (aerial or vessel)</td><td>120-160 hours before, during and after ASW and/or explosives training events</td><td rowspan="4">Adaptive Management Review (AMR) for FY12</td></tr>
<tr><td>Marine Mammal Observers (MMO)</td><td>MMO team aboard Navy surface platforms during 2 ASW and 6 explosive events</td></tr>
<tr><td>Tagging</td><td>Tag a goal of 15 individual marine mammals</td></tr>
<tr><td>Passive Acoustic Monitoring (PAM)</td><td>• Utilize a combination of autonomous recording devices, and/or sonobuoys and/or towed arrays to gather acoustic data. Continue collaboration of data collection and analysis from additional N45/ONR-funded autonomous PAM devices.
• Continue use of the Pacific Missile Range Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.</td></tr>
</table>

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APPENDIX A. Hawaii Range Complex Year Four Monitoring Plan and Adaptive Management Discussion for the period 02 August 2011 to 01 August 2012.

Prepared for
National Marine Fisheries Service
Office of Protected Resources

Prepared by
Department of the Navy
U.S. Pacific Fleet

Hawaii Range Complex

Year Four Monitoring Plan

02 August 2011 to 01 August 2012

01 October 2011

Overview:

Results of recent meetings, recommendations from the SAG as well as success and challenges in the field are under review and will be further discussed with NMFS at the annual adaptive management meeting in October 2011. Results will be used to revise and improve the monitoring progam in the coming years, while maintaining the same level of effort. The Navy assembled a Scientific Advisory Group as well as convened monitoring meetings with NMFS, researchers and non-governmental organizations in October 2010 and June 2011 in the interest of soliciting input on monitoring objectives and methods. The June 2011 "Adaptive Management Meeting" was described in NMFS' Final Rule. The recommendations that were generated during those meetings are currently under review by the Navy and will be further discussed with NMFS at the annual Adaptive Management Meeting in October of 2011. Results will be used to revise and improve the monitoring program in the coming years, while maintaining the same level of overall effort. However, they are not available for incorporation into this Letter of Authorization renewal request.

2012 -2014 Monitoring Commitments

Other than adding more flexible language to allow the PAM section, no changes are being recommended for 2012-2014 at this time. Once review of current monitoring methods and metrics are completed, they will be incorporated into new monitoring plans. There is no firm timeline for this effort, but it is anticipated to be completed in the spring of 2012.

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) STUDIES 1,2,3,4, 5	120-160 hours before, during and after ASW training events including major training exercises (MTE), SCC, Unit Level Training (ULT) and/or explosive events.	Adaptive Management Review (AMR)
Marine Mammal Observers (MMO) STUDIES 1,2,3, 4, 5	MMO team aboard Navy surface platforms during 2 ASW and 6 explosive events	
Tagging STUDIES 1,2, 3	Tag a goal of 15 individual marine mammals	
Passive Acoustic Monitoring (PAM) STUDIES 1,2, 3	- Utilize a combination of autonomous recording devices, and/or sonobuoys and/or towed arrays to gather acoustic data. Continue collaboration of data collection and analysis from additional N45/ONR-funded autonomous PAM devices. Continue data analysis. - Continue use of the Pacific Missile Range Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.	

APPENDIX B. Koa Kai-11 Marine Species Monitoring Surveys, Vessel- and Aerial-based Monitoring Surveys, November 2010. Final Report

Koa Kai-11 Marine Species Monitoring Surveys

VESSEL- AND AERIAL-BASED MONITORING sappSURVEYS
NOVEMBER 2010
FINAL REPORT

Hawaii Range Complex, 2010; NOAA *permit* #14451

JUNE 2011

HDR

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ACRONYMS AND ABBREVIATIONS

ASW	Anti-Submarine Warfare
ESA	Endangered Species Act
HDR EOC	HDR Environmental, Operations and Construction, Inc.
HRC	Hawaii Range Complex
km	kilometer(s)
m	meter(s)
MMPA	Marine Mammal Protection Act
NM	Nautical mile(s)
NM^2	Square nautical miles
NOAA	National Oceanic and Atmospheric Administration
RHIB	Rigid Hulled Inflatable Boat
SPUE	Sightings per Unit of Effort

INTRODUCTION

This report presents the results of marine mammal monitoring for the Koa Kai 11-1 training event, and represents the continued monitoring efforts under the U.S. Navy's Marine Species Monitoring Program (Contract # N62470-10-D-3011; Task Order KB05) issued to HDR Environmental, Operations and Construction, Inc. (HDR|EOC).

As part of compliance requirements with the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973, the U.S. Department of the Navy developed the Hawaii Range Complex (HRC) Monitoring Plan, which provides for monitoring of marine mammals and sea turtles during training exercises (DoN 2008, 2010). Research elements of the plan include visual surveys and passive acoustic monitoring of these animals. To meet the goals outlined in this plan effectively, it was determined that marine mammal and sea turtle monitoring will be conducted during regularly scheduled training events where one or more surface combatants are conducting anti-submarine warfare (ASW) training.

Such a training event was conducted by the U.S. Pacific Fleet during November 12–17, 2010, when the Surface Navy and other combatant units participated in the Koa Kai 11-1 training event in the HRC. The purpose of Koa Kai is to conduct warfare and seamanship evolutions that enable ships to transition from unit-level basic training to more advanced, integrated training; and to exercise in a multi-ship environment that includes submarine and aviation forces with the goal of achieving deployment certificates and training, including ASW.

The marine mammal and sea turtle monitoring, vessel- and aerial-based surveys, were conducted between November 11–23, 2010, before, during, and after the Pacific Fleet training event in the HRC.

The objectives of the vessel-based monitoring effort for Koa Kai 11-1 consisted of the following:

- Perform focal behavioral follows of marine mammals during the course of a training event involving ASW
- Assess the occurrence, distribution, and behavior of target species (marine mammals and sea turtles) using a vessel-based line transect survey within the HRC in waters within or adjacent to the area where ships were training
- Locate individual false killer whales (*Pseudorca crassidens*), pygmy killer whales (*Feresa attenuata*), and short-finned pilot whales (*Globicephala macrorhynchus*) tagged by Dr. Robin Baird with Cascadia Research
- Investigate the occurrence, distribution, and behavior of target species (marine mammals and sea turtles) using vessel-based line transect survey in waters within or adjacent to the area where Navy ships were training.

The objective of the aerial-based monitoring effort for Koa Kai 11-1 was to:

- Assess the occurrence, distribution, and behavior of target species (marine mammals and sea turtles) using a nearshore, aerial-based line transect survey in waters within or adjacent to the area whereNavy ships were training.

METHODS

Study Area

The U.S. Navy's HRC includes the eight main Hawaiian Islands. The marine species monitoring survey was within and adjacent to the area of the training event.

Vessel-Based Monitoring

The vessel-based survey covered an area of approximately 8,000 square nautical miles (NM^2), in an area 80 nautical miles (NM) south of O'ahu, and 60 NM west of the Big Island (Hawai'i). The vessel-based monitoring effort was performed for 12 days over a 14-day period from November 11-23, 2010 (**Tables 1** and **2**). These dates reflect monitoring that occurred before, during, and after the Koa Kai training event that occurred during November 12–17, 2010. Survey methods were consistent with currently accepted Distance Sampling theory (Buckland et al. 2001) and similar to those used in other HRC vessel-based monitoring efforts (Smultea 2008, HDR|e²M 2010). Focal follow methodology was also similar to those used during other HRC vessel- and aerial-based monitoring efforts (Smultea 2008, HDR|e²M 2010).

Table 1. Summary of Koa Kai 11-1 Vessel-Based Monitoring Effort.

Date	Sightings	Total hours
11/11/2010	1	8.3
11/12/2010	1	9.6
11/13/2010	2	6.4
11/14/2010	5	9.5
11/15/2010	0	2.3
11/16/2010	4	8.9
11/18/2010	4	10.8
11/19/2010	4	10.2
11/20/2010	0	9.6
11/21/2010	0	8.3
11/22/2010	5	8.1
11/23/2010	0	3.3
TOTAL	**26**	**95.3**

Table 2. Summary of Koa Kai 11-1 Vessel-Based Monitoring Effort by Trackline Coverage.

Date	On-Effort NM (kilometers [km])	Off-Effort NM (km)	Total daily effort NM (km)
11/11/2010	50.11(92.80)	9.97 (18.46)	60.07 (111.26)
11/12/2010	58.07 (107.55)	12.33 (22.84)	70.40 (130.39)
11/13/2010	26.16 (48.44)	13.11 (24.28)	39.27 (72.72)
11/14/2010	56.99 (105.55)	9.59 (17.75)	66.58 (123.30)
11/15/2010	7.97 (14.76)	12.87 (23.85)	20.85 (38.60)
11/16/2010	55.18 (102.20)	14.85 (27.51)	70.03 (129.71)
11/18/2010	69.41 (128.56)	9.61 (17.79)	79.02 (146.35)
11/19/2010	63.17 (116.99)	17.17 (31.79)	80.34 (148.79)
11/20/2010	70.58 (130.71)	0.32 (0.59)	70.89 (131.29)
11/21/2010	68.26 (126.41)	0.20 (0.38)	68.46 (126.79)
11/22/2010	58.34 (108.04)	7.08 (13.11)	65.42 (121.16)
11/23/2010	22.98 (42.57)	0.31 (0.57)	23.29 (43.14)
TOTAL	**607.22 (1,124.58)**	**107.41 (198.93)**	**714.64 (1,323.51)**

The observation platform for the 12-day period was an 85-foot (25.9-meter [m]) Bertram charter vessel, the *MV Aukele*. The survey effort was based on equally spaced lines running roughly NE to SW with no stratification of survey effort (**Figure 1**). Actual lines of effort varied by sea state, and, therefore, do not match the intended effort. When Beaufort sea state reached 7 or higher, the effort was curtailed. See **Table 3** for details regarding effort by sea state.

Table 3. Summary of Koa Kai 11-1 Vessel-Based Monitoring Effort by Beaufort Sea State.

Beaufort sea state	Total Effort NM (km)	Percentage (%)	# Sightings
0	0 (0)	0.00	0
1	52.03 (28.08)	3.93	1
2	663.31 (358.42)	50.12	20
3	380 (205.04)	28.71	2
4	75.46 (40.72)	5.70	1
5	107.46 (57.98)	8.12	1
6	23.99 (12.94)	1.81	1
7	21.26 (11.46)	1.61	0
TOTAL	**1323.51 (714.64)**	**100.00**	**26**

All six marine mammal observers (**Table 4**) were experienced with line-transect survey methodology, had experience in identification of subtropical Pacific marine mammal and sea turtle species, were knowledgeable of marine mammal biology and behavior, and had previous experience conducting marine mammal observations from vessels. Each observer rotated through three stations at 40-minute intervals: left observer, data recorder, and right observer, followed by a 2-hour rest break. Observers scanned from directly in front to 90 degrees on each side using mounted 25x "Big Eye" reticled binoculars, hand-held 7x reticled binoculars (when ocean swells rendered Big Eye binoculars impractical), or naked eye (when ocean swells rendered hand-held binoculars impractical). When a sighting occurred, the observer noted the horizontal angle to the sighting, the number of reticles down from the horizon, and the sighting cue. The number corresponding to the reticle was used to calculate the distance to the animal based on the height of the platform (6.4 m; 21 feet) and was recorded using WinCruz software (available from the National Oceanic and Atmospheric Administration [NOAA]) and on data sheets). Species identity and diagnostic cues were recorded, and digital photographs obtained when possible. After a sighting occurred, all three observers on duty were assigned the task of projecting independent estimates of group composition using a minimum, maximum, and best estimate approach. The average of the "best" estimates from the three observer team members was then recorded for group size.

Table 4. Observers and Roles for Vessel-Based Monitoring.

Observer	Role(s)
Greg Fulling	Chief Scientist/Observer
Craig Hawkinson	Lead Observer
Tom Kieckhefer	Lead Observer
Mark Cotter	Observer
Tara Leota	Observer
Keri Lestyk	Observer

Aerial-Based Monitoring

Aerial surveys of the shorelines of the Hawaiian islands and islets within the vicinity of the November 2010 Koa Kai-11 training event were performed on November 18 and 22, 2010. Specifically, a Robinson R44 helicopter was flown at an average altitude of 676 feet (206 m) and an average speed of 89 knots, carrying two observers, a pilot, and copilot (**Table 5**). The mission was to survey the coastlines of the four-island region (Maui, Molokai, Kahoolawe, and Lanai and associated islets) and west coast of Hawaii (Big Island) to detect presence and assess behaviors of marine mammals and sea turtles. Special attention was paid to detecting any marine mammals that appeared to be distressed, injured, stranded, or dead.

Table 5. Observers and roles for Aerial-Based Monitoring.

Observer	Role(s)
Joe Mobley	Observer/Data Recorder
Aliza Milette	Observer

The survey protocol consisted of following within 0.6 to 1.2 miles (1 to 2 km) offshore of Molokai, Maui, Molokini, Kahoolawe, Lanai, and the west coast of Hawaii (Big Island) (**Figures 2-5**). GPS locations and altitudes were automatically recorded every 5 seconds using a Garmin WAAS-enabled GPS 296. The two observers watched off their respective sides (i.e., coastal, offshore) with the offshore observer also serving as data recorder. When a sighting occurred, the following data were recorded:

a) Sighting angle (using Suunto handheld clinometers)
b) Species identity (with photos if needed)
c) Composition (e.g., number of adults and number of calves)
d) Reaction to aircraft (i.e., based on changes in behavior upon approach)
e) Behavioral description
f) Direction of travel.

Environmental data, including Beaufort sea state and visibility, were recorded, and changes in sighting conditions were noted. Photographs were taken when species identity or number of individuals was uncertain. A Canon 5D with 200-400 mm Canon telephoto lens was used in such cases. Additionally, a Canon HD digital video camera was available to record any unusual behaviors.

RESULTS

Part 1. Vessel-Based Monitoring

Survey effort

Observers surveyed 714.64 nm (1,323.51 kilometers [km]) of trackline during 12 days for a total of approximately 95.3 hours during the Koa Kai 11-1 monitoring effort. Beaufort sea states ranged from 1 to 7. Sightings were made in all Beaufort sea states except 7 (**Table 6**). Marine mammal sightings per unit of effort (SPUE) was calculated as the total survey effort (hours/nm/km) divided by the total number of marine mammal sightings (*n*=26). For this monitoring effort, the SPUE was equal to 1 sighting per 3.67 hours, 27.49 nm, or 50.90 km.

Sightings

Twenty-six marine mammal sightings representing 11 species were recorded during approximately 95.3 hours of effort (**Table 6** and **Figure 1**). No sea turtles were sighted during the entire survey. Marine mammal sightings consisted of eight groups of short-finned pilot whales, six groups of humpback whales (*Megaptera novaeangliae*), one group of pygmy killer whales (*Feresa attenuata*), one group of beaked whales (*Mesoplodon* spp.), one group of pantropical spotted dolphins (*Stenella attenuata*), one group of rough-toothed dolphins (*Steno bredanensis*), one group of bottlenose dolphins (*Tursiops truncatus*), one minke whale (*Balaenoptera acutorostrata*), one dwarf sperm whale (*Kogia breviceps*), one sei whale (*Balaenoptera borealis*), one false killer whale (*Pseudorca crassidens*), and three sightings of unidentified cetaceans (**Figures 1** and **2; Table 6**). Whenever possible, photographs were taken for species identification and photo-identification purposes during focal follows. A total of 1,567 photographs were taken for 25 sightings. See **Appendix B** for representative photographs.

Table 6. Summary of Sightings During Vessel-Based Monitoring Efforts for Koa Kai 11-1, November 2010.

Sighting number	Date	Species	Group size best/high/low			Calves	Time	Beaufort sea state	Latitude	Longitude	Bottom depth (m)	Bearing	Distance (NM)	Behavioral summary*
1	11/11/10	MN	2	2	2	-	10:29	6	21°17.34'N	157°37.18'W	77	315	0.25	Diving.
2	11/12/10	MN	1	1	1	-	15:10	5	20°58.16'N	157°28.07'W	344	270	0.5	Diving; breached once and did three chin slaps.
3	11/13/10	GM	16	23	11	1	9:23	2	20°46.99'N	157°04.11'W	660	345	2.08	**Focal follow details in Appendix A.** Animals logging at surface or slow traveling.
4	11/13/10	GM	14	25	13	-	10:50	2	20°44.92'N	157°06.36'W	708	30	1.33	Slow traveling.
5	11/14/10	GM	9	13	7	1	8:13	2	20°46.42'N	157°05.72'W	726	335	0.2	**Focal follow details in Appendix A.** Slow traveling, group widely spaced apart.
6	11/14/10	PC	1	1	1	-	9:23	2	20°48.08'N	157°08.44'W	1,072	35	0.3	**Focal follow details in Appendix A.** Fast traveling.
7	11/14/10	GM	21	27	16	2-4	10:48	2	20°45.05'N	157°05.67'W	700	50	1.0	**Focal follow details in Appendix A.** Slow traveling; logging at surface.
8	11/14/10	GM	5	8	3	1	11:16	2	20°43.96'N	157°06.12'W	662	340	0.51	**Focal follow details in Appendix A.** Surface active behavior (spyhop, lobtail); changed direction close to vessel.
9	11/14/10	GM	24	30	17	4-6	12:10	2	20°41.08'N	157°08.21'W	1,055	275	0.86	**Focal follow details in Appendix A.** Multiple groupings of animals; slow traveling.
10	11/16/10	GM	4	7	4	1-2	7:33	2	20°44.38'N	157°03.08'W	622	10	0.51	Slow traveling; widely dispersed group.
11	11/16/10	SA	71	104	51	7-10	7:53	2	20°43.46'N	157°06.03'W	667	0	0.28	**Focal follow details in Appendix A.** Approached vessel to bowride; surface active (jumping); moderate to fast traveling.
12	11/16/10	GM	6	9	5	1-2	8:40	2	20°43.09'N	157°06.72'W	681	355	0.32	Slow traveling.
13	11/16/10	USW	1	1	1	-	11:54	4	20°49.03'N	157°38.81'W	1,119	15	0.86	Breached (no resight).

Sighting number	Date	Species	Group size best/high/low			Calves	Time	Beaufort sea state	Latitude	Longitude	Bottom depth (m)	Bearing	Distance (NM)	Behavioral summary*
14	11/18/10	SB	32	39	24	2-3	9:29	2	19°35.51'N	157°04.75'W	4,347	25	0.11	**Focal follow details in Appendix A.** Approached vessel to bowride; fast traveling.
15	11/18/10	BA	1	1	1	-	12:01	2	19°26.92'N	157°13.41'W	3,745	60	0.13	Fast traveling.
16	11/18/10	ULW	1	1	1	-	12:44	2	19°22.34'N	157°18.01'W	3,209	22	0.86	Only saw blow (no resight).
17	11/18/10	BB	1	1	1	-	13:25	2	19°21.97'N	157°20.88'W	3,106	0	0.71	**Focal follow details in Appendix A.** Evasive behavior; underwater blows; multiple changes of direction.
18	11/19/10	ULW	1	1	1	-	9:19	2	19°24.96'N	157°12.85'W	3,688	90	2.29	Only saw blow (no resight).
19	11/19/10	MS	3	3	3	-	9:37	2	19°24.51'N	157°15.43'W	3,679	10	2.7	Diving.
20	11/19/10	KB	1	1	1	-	12:47	2	19°18.04'N	157°13.43'W	3,469	320	1.46	Logging at surface; diving.
21	11/19/10	FA	20	26	16	1-2	15:20	1	19°25.54'N	157°01.74'W	1,969	40	3.29	**Focal follow details in Appendix A.** Slow travel/logging until vessel approached then evasive behavior; turned and dispersed when vessel was in gear.
22	11/22/10	TT	20	25	17	2-4	10:14	3	20°59.04'N	157°17.42'W	1,047	28	3.29	**Focal follow details in Appendix A.** Approached vessel to bowride; moderate to fast traveling.
23	11/22/10	MN	1	1	1	-	11:06	2	21°02.16'N	157°22.31'W	119	28	2.7	Diving.
24	11/22/10	MN	2	2	2	-	11:36	2	21°05.47'N	157°25.00'W	58	315	0.1	Slow traveling; tail-slap; diving.
25	11/22/10	MN	1	1	1	-	12:01	2	21°06.04'N	157°26.07'W	63	35	1.5	Diving.
26	11/22/10	MN	1	1	1	-	16:09	2	21°16.97'N	157°16.16'W	176	340	2.29	Diving.

Key:
BA = minke whale (*Balaenoptera acutorostrata*)
BB = sei whale (*Balaenoptera borealis*)
FA = pygmy killer whale (*Feresa attenuata*)
GM = short-finned pilot whale (*Globicephala macrorhynchus*)
KB = dwarf sperm whale (*Kogia breviceps*)
MN = humpback whale (*Megaptera novaeangliae*)
MS = *Mesoplodon* spp.
PC = false killer whale (*Pseudorca crassidens*)
SB = rough-toothed dolphin (*Steno bredanensis*)
SA = pantropical spotted dolphin (*Stenella attenuata*)
TT = bottlenose dolphin (*Tursiops truncatus*)
ULW = unidentified large whale
USW = unidentified small whale
* Behavioral summaries compiled from WinCruz comments and sighting sheets

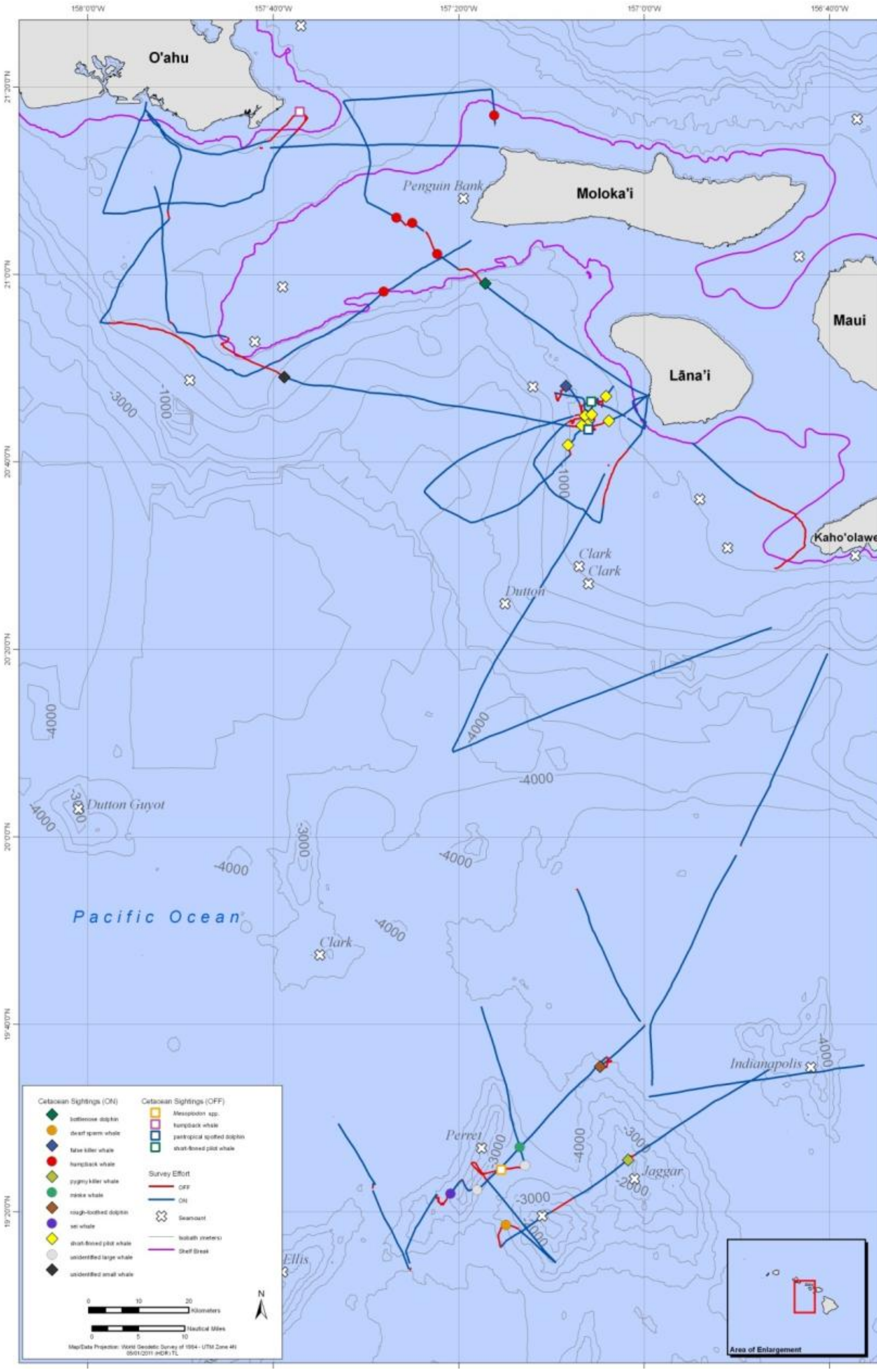

Figure 1. Locations of marine mammal sightings and tracklines during vessel-based monitoring efforts for Koa Kai 11-1, November 2010.

Figure 2. Sei whale (Balaenoptera borealis) sighted on November 18, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Navy vessels were observed twice during the survey (on 11/12/10 and 11/22/10); however, no marine mammal sightings occurred while these vessels were within sight.

Attempts were made to locate individual false killer whales, pygmy killer whales, and short-finned pilot whales that had been tagged by Dr. Robin Baird with Cascadia Research. None of those individuals were seen.

Behavior

The team was able to conduct five focal follows of short-finned pilot whales (Sightings 3, 5, 7, 8, and 9), one focal follow on a false killer whale (Sighting 6), one focal follow on pantropical spotted dolphins (Sighting 11), one focal follow on rough-toothed dolphins (Sighting 14), one focal follow on a sei whale (Sighting 17), one focal follow on pygmy killer whales (Sighting 21), and one focal follow on bottlenose dolphins (Sighting 22). During the majority of sightings the animals did not react to the survey vessel and continued their original course and speed. However, there were some cases where animals appeared to react to the vessel or were evasive (Sightings 6, 7, 17, and 21). Detailed behavioral observations made during the focal follows are presented in **Appendix A**.

Part 2. Aerial-Based Monitoring

Survey effort

A linear distance of 1,443 miles (2,322 km) was surveyed during 2 days for a total of 14.1 hours during and after the Koa Kai 11-1 training event (**Figures 3-6**). Beaufort sea states ranged from 2 to 4, with a mean of 3 (**Table 7**).

Table 7. Summary of Shoreline Aerial Survey Effort During Koa Kai-11 in November 2010.

Date	Start Time (depart HNL)	End Time (return to HNL)	Effort (hrs)*	Effort (km)	Mean Beaufort Sea State
Nov. 18	0739	1558	7.1	1172	3.0
Nov. 22	0740	1543	7.0	1150	3.0
TOTAL			**14.1 hrs**	**2322 km**	**3.0**

Note: * excludes down time for refueling

Sightings

A total of 125 sightings were recorded of four identified cetacean species (spinner dolphin, bottlenose dolphin, false killer whale, humpback whale), and unidentified delphinids and turtles during 14.1 hours of effort (**Tables 7-9**). The majority of groups sighted were unidentified sea turtle species (81%; *n*=101) followed by spinner dolphins (11%; *n*=14). No instances of distressed, injured, stranded, or dead marine mammals were observed (**Tables 7** and **8**).

Table 8. Summary of Species Sighted During Koa Kai-11 Aerial Surveys in November 2010.

Species	Number groups	Number individuals (best estimate)	Sightings/km surveyed
Bottlenose dolphin	1	1	.0004
False killer whale	1	5	.0004
Humpback whale	2	2	.0009
Spinner dolphin	14	607	.0060
Unidentified delphinid	6	77	.0026
Unidentified turtle spp.	101	162	.0435
TOTAL	**125**		

Photos were only taken for one sighting: a pod of false killer whales (*Pseudorca crassidens*). Most photos of this sighting were unfortunately of poor quality, and in only one photo are the animals clearly distinguishable (Sighting 122, **Appendix B).**

Table 9. Detailed List of Sightings during Aerial-Based Surveys During Koa Kai-11, November 2010.

Sighting Number	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Altitude (ft)	Direction	Angle	Reaction	Behavior
1	11/18/10	UT	1	1	1	-	7:47:34	2	21.2673	157.8323	447	90	45	N	
2	11/18/10	UT	1	1	1	-	7:50:28	2	21.2681	157.766	538	270	50	N	
3	11/18/10	SL	23	28	15	2	7:51:23	2	21.2722	157.715	472	--	10	N	milling; slow swimming
4	11/18/10	UT	2	2	2	-	7:54:43	2	21.2565	157.7035	715	45	50	N	
5	11/18/10	UD	50	60	40	-	8:10:58	2	21.2182	157.2878	904	--	50	N	milling
6	11/18/10	UT	8	8	8	-	8:15:23	2	21.1756	157.2634	896	135	30	N	
7	11/18/10	UT	1	1	1	-	8:19:28	2	21.0897	157.2989	920	90	45	N	
8	11/18/10	UT	1	1	1	-	8:21:28	2	21.0793	157.2547	798	90	60	N	
9	11/18/10	UT	2	2	2	-	8:35:38	2	20.9608	157.0095	849	270	25	N	
10	11/18/10	SL	110	120	100	-	8:58:13	4	20.7471	156.8523	1037	270	55	N	slow swimming
11	11/18/10	UT	1	1	1	-	9:01:38	4	20.7694	156.824	962	45	30	N	
12	11/18/10	UT	3	3	3	-	9:02:08	4	20.7802	156.817	956	270	50	N	
13	11/18/10	UT	1	1	1	-	9:02:33	4	20.7892	156.8106	956	270	55	N	
14	11/18/10	UT	5	5	5	-	9:02:48	4	20.7948	156.8071	969	90	60	N	
15	11/18/10	UT	1	1	1	-	9:07:48	4	20.9006	156.8721	724	180	40	N	
16	11/18/10	UT	1	1	1	-	9:10:08	4	20.9267	156.9322	1063	90	40	N	
17	11/18/10	UT	1	1	1	-	9:12:43	4	20.9463	157.0073	819	270	50	N	
18	11/18/10	UT	1	1	1	-	9:18:03	2	21.0713	157.0001	786	315	60	N	
19	11/18/10	UT	1	1	1	-	9:28:28	2	21.1045	156.7413	655	90	40	N	
20	11/18/10	UT	1	1	1	-	9:29:33	2	21.1246	156.7207	688	225	40	N	
21	11/18/10	UT	1	1	1	-	9:35:08	2	21.013	156.6507	593	225	40	N	
22	11/18/10	UT	6	6	6	-	9:36:43	2	20.9815	156.6797	735	90	55	N	
23	11/18/10	UT	2	2	2	-	9:37:53	2	20.951	156.694	696	90	55	N	
24	11/18/10	UT	3	3	3	-	9:38:48	2	20.9338	156.7014	713	135	55	N	
25	11/18/10	UT	1	1	1	-	9:40:08	2	20.922	156.6989	647	180	60	N	
26	11/18/10	UT	1	1	1	-	9:42:43	2	20.864	156.6782	1000	270	35	N	
27	11/18/10	UT	1	1	1	-	9:44:48	2	20.8201	156.6374	912	90	45	N	
28	11/18/10	UT	2	2	2	-	9:48:58	2	20.7897	156.5815	920	90	55	N	
29	11/18/10	UT	1	1	1	-	9:51:28	2	20.7816	156.5135	929	270	40	N	
30	11/18/10	SL	24	30	19	-	9:59:44	2	20.5926	156.6099	746	270	60	N	milling

Sighting Number	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Altitude (ft)	Direction	Angle	Reaction	Behavior
31	11/18/10	SL	35	40	30	-	10:01:55	2	20.5902	156.6096	251	--	90	N	2 groups separated; milling
32	11/18/10	UT	5	5	5	-	11:23:47	2	20.7299	156.457	579	90	40	N	
33	11/18/10	SL	100	120	80	-	11:24:08	2	20.7211	156.4538	500	--	50	N	milling; spinning
34	11/18/10	UT	2	2	2	-	11:27:48	4	20.6925	156.4479	619	135	45	N	
35	11/18/10	UT	1	1	1	-	11:29:36	4	20.6501	156.4474	560	90	40	N	
36	11/18/10	UD	12	12	12	-	11:40:42	4	20.605	156.2407	718	270	50	N	slow swimming; not resighted
37	11/18/10	UT	1	1	1	-	12:02:24	2	20.264	155.9035	538	90	40	N	
38	11/18/10	UT	1	1	1	-	12:10:26	2	20.1203	155.8898	614	315	50	N	
39	11/18/10	SL	36	40	30	-	12:45:25	3	19.478	155.9306	485	--	50	N	milling
40	11/18/10	SL	15	18	12	-	14:20:32	3	20.6447	156.0766	608	90	45	N	slow swimming
41	11/18/10	UT	1	1	1	-	14:27:30	3	20.7407	155.98	543	135	30	N	
42	11/18/10	UT	6	6	6	-	14:48:02	5	20.9202	156.3907	510	90	25	N	
43	11/18/10	UT	1	1	1	-	14:51:38	2	20.9081	156.4765	562	270	28	N	
44	11/18/10	TT	1	1	1	-	15:27:32	3	21.2224	157.2387	606	90	25	N	jumped then slow swimming
45	11/22/10	SL	40	50	30	-	7:44:24	2	21.2663	157.8317	543	--	50	N	milling
46	11/22/10	UT	1	1	1	-	7:46:19	2	21.2697	157.838	401	90	55	N	
47	11/22/10	UT	1	1	1	-	7:56:28	2	21.281	157.6708	461	135	55	N	
48	11/22/10	UT	1	1	1	-	7:56:38	2	21.2839	157.667	467	270	55	N	
49	11/22/10	UT	1	1	1	-	7:56:58	2	21.289	157.6592	497	90	55	N	
50	11/22/10	UT	1	1	1	-	7:57:08	3	21.2916	157.6555	513	90	55	N	
51	11/22/10	SL	28	32	24	-	8:22:03	2	21.0807	157.2602	866	270	45	N	slow swimming
52	11/22/10	UT	2	2	2	-	8:31:18	2	21.0767	157.028	858	90	50	N	
53	11/22/10	UD	6	6	6	-	8:49:08	2	20.7399	156.9727	440	--	55	C	milling by cliff face
54	11/22/10	SL	42	50	35	-	8:51:13	2	20.7306	156.9448	839	--	60	N	milling, two groups
55	11/22/10	UT	1	1	1	-	9:07:48	2	20.9006	156.8721	724	90	55	N	
56	11/22/10	UT	2	2	2	-	9:08:53	3	20.9179	156.8969	868	270	55	N	
57	11/22/10	UT	1	1	1	-	9:08:58	3	20.919	156.8992	852	270	50	N	
58	11/22/10	UT	1	1	1	-	9:09:53	3	20.9259	156.9251	1035	90	50	N	
59	11/22/10	UT	2	2	2	-	9:10:18	3	20.9273	156.9372	1054	135	50	N	
60	11/22/10	UT	1	1	1	-	9:11:13	3	20.9301	156.9665	951	270	50	N	
61	11/22/10	UT	1	1	1	-	9:11:18	3	20.9306	156.9692	918	90	50	N	

Sighting Number	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Altitude (ft)	Direction	Angle	Reaction	Behavior
62	11/22/10	UT	1	1	1	-	9:17:18	2	21.0724	157.0216	902	225	50	N	
63	11/22/10	UT	1	1	1	-	9:18:58	2	21.0645	156.9755	863	90	45	N	
64	11/22/10	UT	5	5	5	-	9:19:23	2	21.0618	156.9648	861	90	40	N	
65	11/22/10	UT	1	1	1	-	9:25:48	4	21.0644	156.799	718	90	50	N	
66	11/22/10	UT	1	1	1	-	9:25:53	4	21.0653	156.7971	726	180	55	N	
67	11/22/10	UT	2	2	2	-	9:26:53	4	21.0787	156.7749	671	270	55	N	
68	11/22/10	UT	1	1	1	-	9:27:23	3	21.0868	156.7642	666	180	40	N	
69	11/22/10	UT	3	3	3	-	9:27:53	3	21.0947	156.7535	628	315	40	N	
70	11/22/10	UT	1	1	1	-	9:28:13	3	21.1	156.7463	631	90	35	N	
71	11/22/10	UT	1	1	1	-	9:28:48	3	21.1107	156.7351	669	270	65	N	
72	11/22/10	UT	2	2	2	-	9:29:03	2	21.1157	156.7309	658	270	80	N	
73	11/22/10	UT	1	1	1	-	9:37:53	2	20.951	156.694	696	270	50	N	
74	11/22/10	SL	12	14	10	-	9:38:28	2	20.9349	156.6975	708	--	10	N	milling
75	11/22/10	UT	2	2	2	-	9:39:53	2	20.9273	156.6974	641	90	60	N	
76	11/22/10	UT	1	1	1	-	9:40:43	2	20.9096	156.6948	732	90	45	N	
77	11/22/10	UT	1	1	1	-	9:40:58	2	20.9047	156.6915	748	270	45	N	
78	11/22/10	UT	1	1	1	-	9:41:03	2	20.9027	156.6909	764	315	35	N	
79	11/22/10	UT	1	1	1	-	9:41:08	2	20.9008	156.6902	803	270	40	N	
80	11/22/10	UT	3	3	3	-	9:41:48	2	20.8843	156.6906	917	45	55	N	
81	11/22/10	UT	1	1	1	-	9:43:13	2	20.8535	156.6681	967	90	50	N	
82	11/22/10	UT	2	2	2	-	9:44:28	2	20.8269	156.6446	962	270	50	N	
83	11/22/10	UT	1	1	1	-	9:44:38	2	20.8236	156.6409	939	270	40	N	
84	11/22/10	UD	1	1	1	-	9:45:08	2	20.8124	156.6315	863	45	30	N	dove
85	11/22/10	UT	1	1	1	-	9:46:58	2	20.8134	156.6324	641	180	45	N	
86	11/22/10	UT	1	1	1	-	9:47:53	2	20.8037	156.61	776	45	50	N	
87	11/22/10	UT	5	5	5	-	9:48:03	2	20.8018	156.6054	762	45	45	N	
88	11/22/10	UT	1	1	1	-	9:50:18	2	20.7746	156.544	928	90	30	N	
89	11/22/10	UT	1	1	1	-	9:50:33	2	20.7718	156.537	912	90	40	N	
90	11/22/10	UT	1	1	1	-	9:51:33	2	20.7832	156.5119	925	90	40	N	
91	11/22/10	UT	2	2	2	-	9:51:48	2	20.7883	156.5072	907	90	60	N	
92	11/22/10	UT	1	1	1	-	10:33:13	2	20.7865	156.4762	578	135	30	N	
93	11/22/10	UT	1	1	1	-	10:33:48	2	20.7756	156.4634	504	225	50	N	
94	11/22/10	UT	1	1	1	-	10:34:18	2	20.7615	156.4627	537	180	30	N	

Sighting Number	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Altitude (ft)	Direction	Angle	Reaction	Behavior
95	11/22/10	UT	3	3	3	-	10:34:58	2	20.7434	156.4607	593	45	45	N	
96	11/22/10	UT	4	4	4	-	10:35:23	2	20.7321	156.4571	598	90	30	N	
97	11/22/10	UT	1	1	1	-	10:35:43	2	20.7237	156.4518	565	90	35	N	
98	11/22/10	UT	1	1	1	-	10:36:18	2	20.708	156.4495	606	135	50	N	
99	11/22/10	UT	1	1	1	-	10:36:28	2	20.7034	156.4494	606	180	35	N	
100	11/22/10	UT	1	1	1	-	10:36:38	2	20.6991	156.4494	641	270	45	N	
101	11/22/10	UT	1	1	1	-	10:36:58	2	20.6903	156.4481	619	90	35	N	
102	11/22/10	UT	1	1	1	-	10:37:08	2	20.6858	156.4477	614	90	40	N	
103	11/22/10	UT	1	1	1	-	10:37:13	2	20.6835	156.4478	617	90	40	N	
104	11/22/10	UT	1	1	1	-	10:37:18	2	20.6813	156.4478	622	90	45	N	
105	11/22/10	UT	1	1	1	-	10:37:33	2	20.6746	156.4479	631	225	55	N	
106	11/22/10	UT	1	1	1	-	10:37:38	2	20.6723	156.4479	628	225	45	N	
107	11/22/10	UT	1	1	1	-	10:38:18	2	20.6545	156.4471	661	135	45	N	
108	11/22/10	UT	1	1	1	-	10:38:23	2	20.6524	156.4474	669	90	55	N	
109	11/22/10	UT	1	1	1	-	10:39:03	2	20.6366	156.4549	608	45	45	N	
110	11/22/10	UT	1	1	1	-	10:40:03	2	20.6148	156.4433	664	225	25	N	
111	11/22/10	SL	50	55	45	-	10:44:18	2	20.5935	156.549	568	--	40	N	close inshore, tight milling, heading offshore
112	11/22/10	MN	1	1	1	-	10:48:43	2	20.607	156.5781	559	135	45	N	
113	11/22/10	SL	52	56	45	-	10:51:13	3	20.5903	156.6123	720	--	30	N	milling inside bay, spinning
114	11/22/10	UT	1	1	1	-	11:04:48	3	20.5121	156.5422	537	180	45	N	
115	11/22/10	UT	1	1	1	-	11:05:43	2	20.5295	156.5301	507	360	50	N	
116	11/22/10	UT	2	2	2	-	11:11:38	2	20.5927	156.434	750	270	30	N	
117	11/22/10	UT	1	1	1	-	11:11:43	2	20.5929	156.4316	746	270	40	N	
118	11/22/10	UT	1	1	1	-	11:11:58	2	20.5926	156.4245	705	270	40	N	
119	11/22/10	UD	3	3	3	-	12:09:58	3	19.7348	156.0583	330	270	30	N	near Kona approach area; quick surfacing and dives
120	11/22/10	SL	40	45	35	-	12:17:03	3	19.637	155.9977	469	270	12	N	slow swimming
121	11/22/10	UD	5	5	5	-	12:43:28	4	19.4798	155.9282	598	??	20	N	not resighted

Sighting Number	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Altitude (ft)	Direction	Angle	Reaction	Behavior
122	11/22/10	PC	5	5	5	-	13:40:30	4	19.918	156.0132	795	270	20	N	breaching 2+2+1 line astern (photos)
123	11/22/10	UT	1	1	1	-	14:40:11	4	20.9404	156.3488	410	270	35	N	
124	11/22/10	UT	2	2	2	-	14:41:06	4	20.9316	156.373	565	270	45	N	
125	11/22/10	MN	1	1	1	-	14:57:31	3	21.1597	156.7079	663	45	25	N	slow swimming then dive

Species Key:
TT = bottlenose dolphin
PC = false killer whale
MN = humpback whale
SL = spinner dolphin
UD = unidentified delphinid species
UT = unidentified sea turtle species

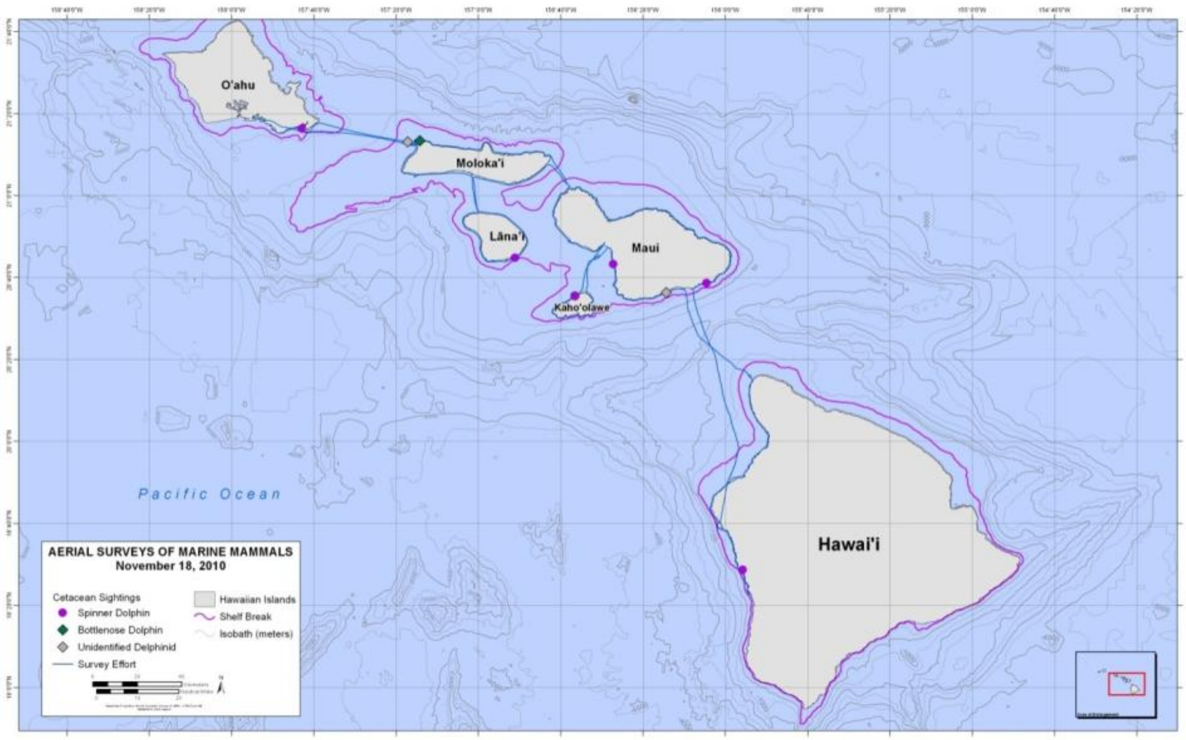

Figure 3. Locations of marine mammal sightings and tracklines during aerial-based monitoring efforts for Koa Kai 11-1, November 18, 2010.

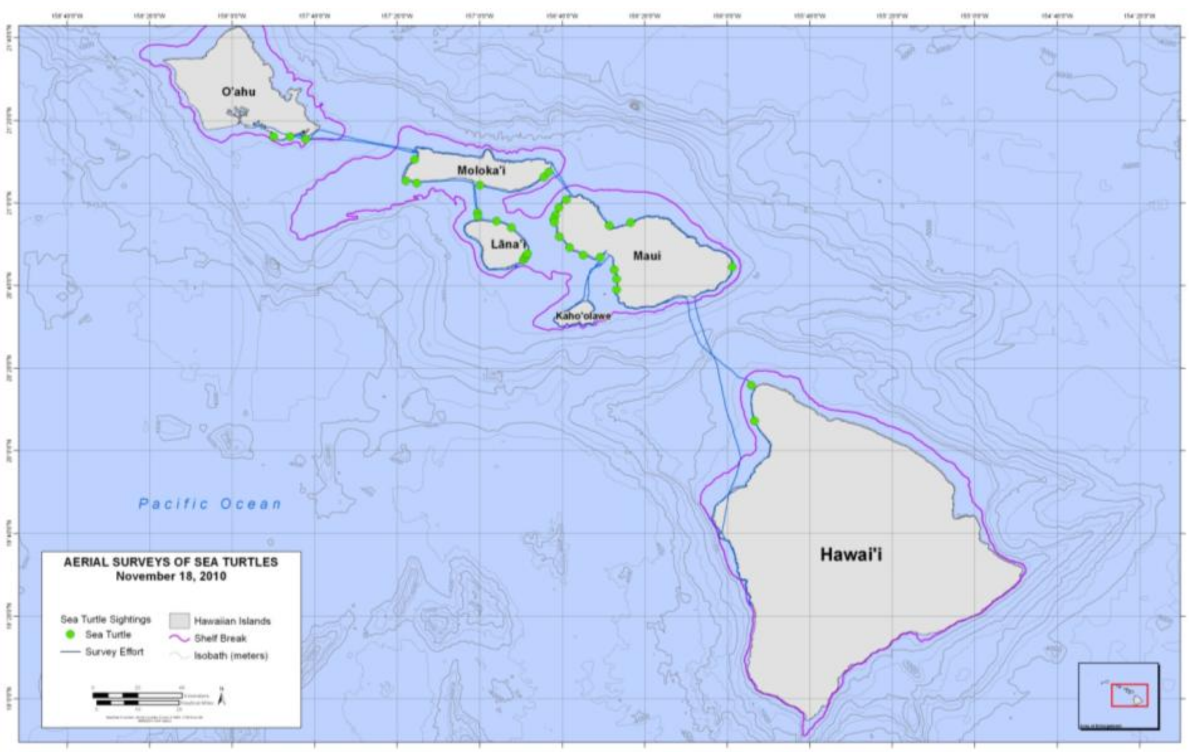

Figure 4. Locations of sea turtle sightings and tracklines during aerial-based monitoring efforts for Koa Kai 11-1, November 18, 2010.

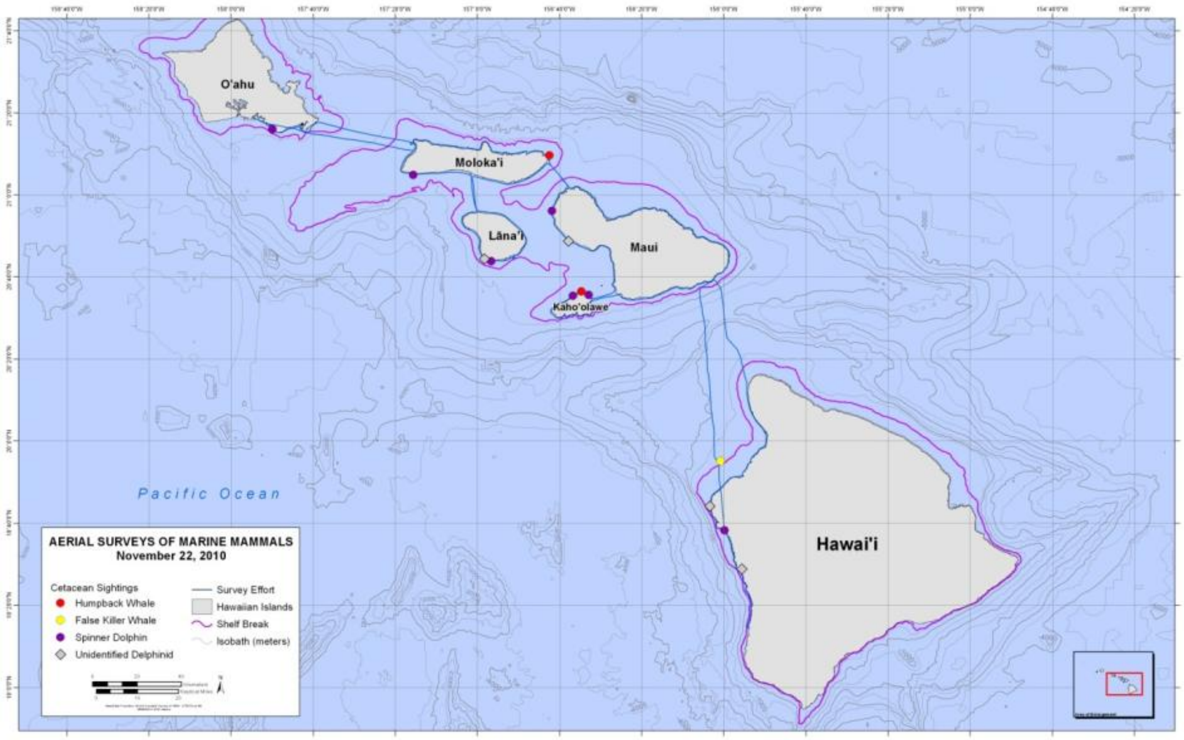

Figure 5. Locations of marine mammal sightings and tracklines during aerial-based monitoring efforts for Koa Kai 11-1, November 22, 2010.

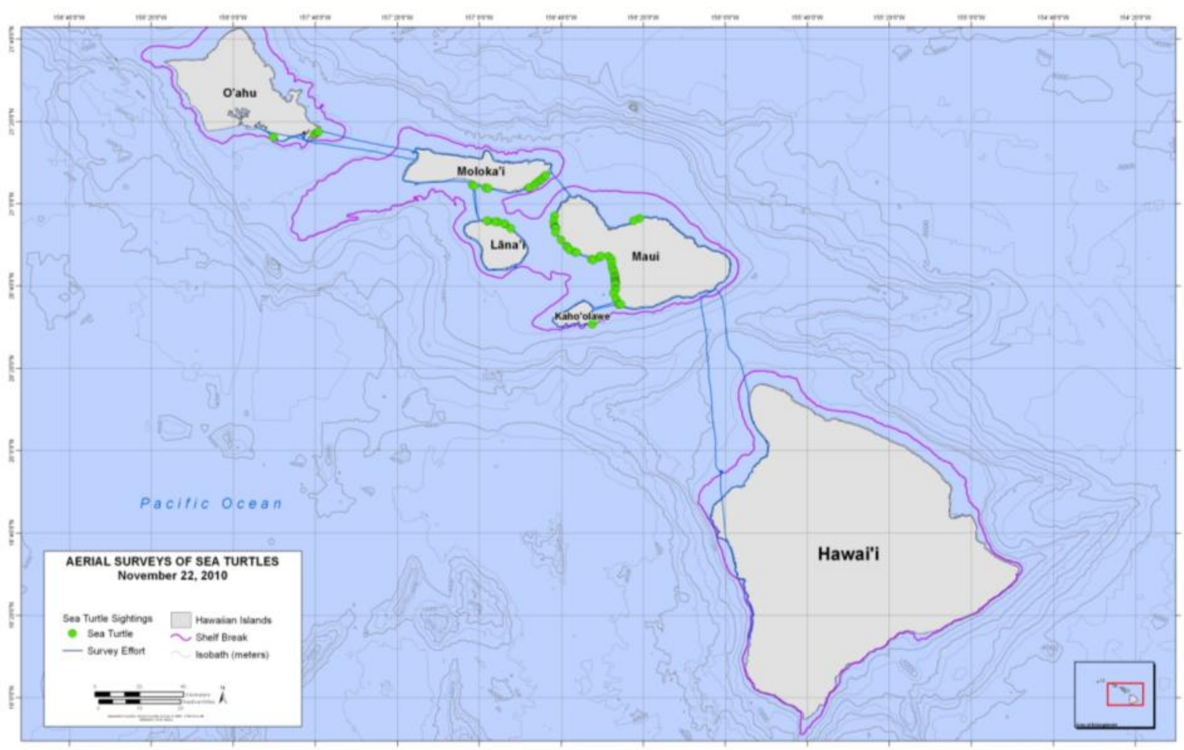

Figure 6. Locations of sea turtle sightings and tracklines during vessel-based monitoring efforts for Koa Kai 11-1, November 22, 2010.

4. RECOMMENDATIONS

Future surveys could benefit from use of a directional hydrophone on the vessel, which would potentially increase the number of focal follows. During time periods when winds are calm and sighting conditions are more optimal, the directional hydrophone could allow the observers to visually locate those animals detected acoustically.

Future monitoring events would be enhanced with the addition of satellite tagging efforts 2 to 3 months in advance of the vessel survey. This would allow more opportunities to establish movement patterns of the animals in the region before, during, and after the training exercise to attain the goals of the HRC Monitoring Plan.

The vessel-based monitoring survey benefited from the decision to remain in the lee of the larger islands during high sea states. In general, this allows more opportunities to observe cetaceans and is preferable to expending time and energy battling sea state. However, caution should be used by future surveys not to depend completely on this effort since it might be quite far from where the actual exercises will be conducted.

This survey benefited from having alternative tracklines planned in advance (e.g., lines over seamounts) and allowed a greater encounter rate for the survey. Again, caution should be used in choosing alternative lines. Our survey encountered unusually low sea states (BSS < 2) while we were in the area of the seamounts. While fortuitous, these opportunities do not happen often.

Future monitoring surveys need to focus on the actual purpose of the monitoring. If the desire is to encounter animals for tagging or focal follows, then it is beneficial to seek out areas of higher density of animals. However, if the purpose is to determine distribution, species richness, or abundance, strict line-transect techniques should be used. That is not to say that a combination of the two approaches can't be used.

The utility of the *Aukele* for future surveys depends on what the actual question/goal of the survey is. The *Aukele* crew was dependable and willing to do anything to assist with the survey. The vessel was not as stable as we had hoped, but did have a flying bridge that served as an excellent vantage point for sightings. The owner of this vessel has agreed to add stabilizers to the vessel for future surveys and the vessel has an adequate rear deck to allow the launching of a small Rigid-Hulled Inflatable Boat (RHIB).

Future surveys, when it is expected to work within sight of the Navy vessels, should incorporate more interaction with the actual vessels in some way to ensure the monitoring vessel is kept up to date on daily maneuvering and other information. Unless this is done, the likelihood of the survey vessel finding the Navy vessels is not good.

5. ACKNOWLEDGEMENTS

We would like to thank Captain Randy Cates of the *Aukele*, and the ship's deckhands Kaipo Miller and Brennan Paakaula for their able assistance during this survey effort. Mahalo to Richard Schuman and Mike Stroup of Makani Kai Helicopters for their superb piloting. These data were obtained under NOAA permit no. 14451 issued to Joseph R. Mobley, Jr., Ph.D.

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KOA KAI-11: APPENDIX A

Focal Follow Data

Table A-1 shows the focal follow behavioral data from the Koa Kai 11-1 vessel monitoring efforts. Behavioral data are a compilation of comments recorded in WinCruz and sighting sheets.

Table A-1. Focal follow behavior data

Record number	Time	Date	Latitude	Longitude	Recorded behavior
Sighting Number 3					
Species: *Globicephala macrorhynchus*					
1	9:47:17	11/13/10	N20:46.11	W157:04.81	Animals sitting at surface/logging.
2	9:48:43	11/13/10	N20:46.13	W157:04.93	Definitely a calf in the group.
3	9:51:03	11/13/10	N20:46.17	W157:04.97	Two separate groups approximately 100 m apart.
4	9:51:37	11/13/10	N20:46.20	W157:04.98	Farther group approaching vessel.
5	9:52;11	11/13/10	N20:46.22	W157:04.99	Majority of group dove.
6	9:56:55	11/13/10	N20:46.33	W157:04.94	Group appeared behind vessel.
7	9:58:37	11/13/10	N20:46.32	W157:04.90	Animals approaching vessel; slow traveling.
8	10:10:11	11/13/10	N20:46.52	W157:04.97	Two groups of animals that are 30 m apart.
9	10:17:02	11/13/10	N20:46.45	W157:05.17	Animals slow moving, short dives of ~5 minutes.
10	10:17:29	11/13/10	N20:46.44	W157:05.16	Groups now spaced 200 m apart.
11	10;20:55	11/13/10	N20:46.66	W157:05.03	Side display from one animal; all logging at surface.
12	10:25:25	11/13/10	N20:46.72	W157:05.02	Animals diving and milling, several changing directions.
13	10:29:09	11/13/10	N20:46.73	W157:05.03	Leaving group.
Sighting Number 5					
Species: *Globicephala macrorhynchus*					
1	8:32:40	11/14/10	N20:45.91	W157:06.75	Two groups widely spaced apart and several single animals with lots of distance in between.
2	8:34:27	11/14/10	N20:45.83	W157:06.75	Animals are low swimming; slow traveling; no large blows.
3	8:36:03	11/14/10	N20:45.77	W157:06.82	Smaller animal appears to be a calf.
4	8:41:04	11/14/10	N20:45.68	W157:06.76	Slow traveling animals; appears to be one group now.
5	8:42:51	11/14/10	N20:45.62	W157:06.76	Group changed directions and dove.

Record number	Time	Date	Latitude	Longitude	Recorded behavior
Sighting Number 5 (continued)					
6	8:55:32	11/14/10	N20:45.25	W157:06.77	Slow traveling; animals widely spaced except for cow/calf pair.
7	8:59:06	11/14/10	N20:45.53	W157:06.81	End of sighting.
Sighting Number 6					
Species: *Pseudorca crassidens*					
1	9:32:21	11/14/10	N20:47.76	W157:08.62	Animal fast traveling; ~4 knots.
2	9:33:01	11/14/10	N20:47.70	W157:08.67	Animal fast traveling and splashing.
3	9:35:47	11/14/10	N20:47.58	W157:08.99	Animal arched and performed a lateral tail display.
4	9:41:36	11/14/10	N20:47.47	W157:08.96	Animal moving fast.
5	9:56:47	11/14/10	N20:46.53	W157:09.28	Animal is being evasive.
6	10:04:15	11/14/10	N20:46.90	W157:09.49	End of sighting.
Sighting Number 7					
Species: *Globicephala macrorhynchus*					
1	10:57:15	11/14/10	N20:44.78	W157:05.54	Evasive behavior; changed direction 180 degrees as vessel approached.
2	10:57:15	11/14/10	N20:44.78	W157:05.54	Several juveniles/young animals in group.
3	10:57:49	11/14/10	N20:44.78	W157:05.53	Slow traveling.
4	10:58:53	11/14/10	N20:44.77	W157:05.52	Closest approach ~100 yards off of stern.
5	11:04:18	11/14/10	N20:44.69	W157:05.44	End of sighting.
Sighting Number 8					
Species: *Globicephala macrorhynchus*					
1	11:32:00	11/14/10	N20:43.67	W157:06.27	Spyhop.
2	11:34:49	11/14/10	N20:43.59	W157:06.23	Changed direction near vessel.
3	11:35:02	11/14/10	N20:43.61	W157:06.23	Closest approach ~20 m.
4	11:38:33	11/14/10	N20:43.61	W157:06.31	Lobtail.
5	11:42:21	11/14/10	N20:43.68	W157:06.47	End of sighting.
Sighting Number 9					
Species: *Globicephala macrorhynchus*					
1	12:17:40	11/14/10	N20:41.07	W157:08.00	Slow traveling and logging; small individuals.
2	12:22:00	11/14/10	N20:40.99	W157:08.03	Three subgroups; echelon near vessel.
3	12:22:37	11/14/10	N20:40.99	W157:08.02	Subgroups off of bow were within three body lengths of each other.
4	12:23:18	11/14/10	N20:40.99	W157:08.02	Separation between groups on stern and bow > 50–100 m.

Record number	Time	Date	Latitude	Longitude	Recorded behavior
Sighting Number 9 (continued)					
5	12:23:50	11/14/10	N20:40.99	W157:08.02	Vessel in neutral; animals slow travel/logging near vessel.
6	12:24:10	11/14/10	N20:40.99	W157:08.01	Group off of bow has small calf.
7	12:24:59	11/14/10	N20:40.97	W157:08.00	Spyhop in bow group; bow and stern groups appear to be coalescing .
8	12:27:05	11/14/10	N20:40.85	W157:07.93	Slow travel by both groups.
9	12:32:38	11/14/10	N20:40.71	W157:08.03	End of sighting.
Sighting Number 11					
Species: *Stenella attenuata*					
1	7:54:07	11/16/10	N20:43.41	W157:06.01	Dolphins ~ 400 m off of bow.
2	8:00:45	11/16/10	N20:43.29	W157:05.64	Several calves; animals jumping and bowriding.
3	8:04:22	11/16/10	N20:43.32	W157:05.54	Several animals are bowriding and coming into contact with the vessel; no evasive behavior.
4	8:14:39	11/16/10	N20:43.55	W157:05.40	School was widely dispersed.
5	8:27:24	11/16/10	N20:43.81	W157:05.52	End of sighting.
Sighting Number 14					
Species: *Steno bredanensis*					
1	9:57:26	11/18/10	N19:36.09	W157:03.84	Potentially two separate groups of animals near float.
2	10:03:30	11/18/10	N19:36.12	W157:03.59	Loosely aggregated group; approaching vessel.
3	10:03:39	11/18/10	N19:36.13	W157:03.60	Several animals bowriding.
4	10:08:04	11/18/10	N19:36.08	W157:03.79	No juveniles in group.
5	10:09:45	11/18/10	N19:36.02	W157:03.86	Animals have converged into one group.
6	10:10:24	11/18/10	N19:35.98	W157:03.78	Some cookiecutter scars; one animal has several entanglement scars.
7	10:11:51	11/18/10	N19:36.06	W157:03.68	Animals have been staying within 200 m of floating debris.
8	10:20:37	11/18/10	N19:36.21	W157:03.91	End of sighting.
Sighting Number 17					
Species: *Balaenoptera borealis*					
1	13:43:54	11/18/10	N19:20.98	W157:21.59	Whale performed two blows then dove ~10 minutes.
2	14:03:43	11/18/10	N19:20.99	W157:22.06	Animal is being evasive; underwater blows.

Record number	Time	Date	Latitude	Longitude	Recorded behavior
Sighting Number 17 (continued)					
3	14:07:49	11/18/10	N19:21.22	W157:22.25	Continuing evasive behavior; low swimming and changing directions.
4	14:08:34	11/18/10	N19:21.19	W157:22.17	Footprints visible; underwater blows.
5	14:24:44	11/18/10	N19:21.60	W157:22.47	End of sighting.
Sighting Number 21					
Species: *Feresa attenuata*					
1	15:29:06	11/19/10	N19:25.63	W157:01.62	Animals are being evasive.
2	15:37:01	11/19/10	N19:25.91	W157:01.43	Group split.
3	15:37:35	11/19/10	N19:25.95	W157:01.49	Group increasing speed.
4	15:44:05	11/19/10	N19:25.94	W157:01.23	Animals are reacting to vessel; when vessel increases speed, animals turn and disperse; when vessel returns to neutral, animals return to slow travel/logging and closely group together.
5	15:48:14	11/19/10	N19:26.02	W157:01.11	End of sighting.
Sighting Number 22					
Species: *Tursiops truncatus*					
1	10:21:36	11/22/10	N20:59.83	W157:18.06	Many small blows.
2	10:30:19	11/22/10	N21:00.57	W157:19.16	Slow traveling.
3	10:32:36	11/22/10	N21:00.54	W157:19.41	Group approaching vessel to bowride.
4	10:32:49	11/22/10	N21:00.54	W157:19.43	Several calves.
5	10:34:49	11/22/10	N21:00.51	W157:19.57	Staying within close proximity to vessel.
6	10:37:16	11/22/10	N21:00.50	W157:19.82	End of sighting.

KOA KAI-11: APPENDIX B

Representative photographs from sightings made during Koa-Kai 11-1 vessel and aerial surveys, November 2010

Sighting 1: Humpback whale (Megaptera novaeangliae) sighted on November 11, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 3: Short-finned pilot whale (Globicephala macrorhynchus) sighted on November 13, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 4: Short-finned pilot whales (Globicephala macrorhynchus) sighted on November 13, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 5: Short-finned pilot whales (Globicephala macrorhynchus) sighted on November 14, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 6: False killer whale (Pseudorca crassidens) with cookie cutter shark bite. Sighted on November 14, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 7: Short-finned pilot whales (Globicephala macrorhynchus) sighted on November 13, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 8: Short-finned pilot whale (Globicephala macrorhynchus) sighted on November 14, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 9: Short-finned pilot whale (Globicephala macrorhynchus) sighted on November 14, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 11: Pantropical spotted dolphin (Stenella attenuata) with calf, sighted on November 16, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 12: Short-finned pilot whales (Globicephala macrorhynchus) sighted on November 16, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 14: Rough-toothed dolphins (Steno bredanensis) sighted on November 18, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 17: Sei whale (Balaenoptera borealis) sighted on November 18, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

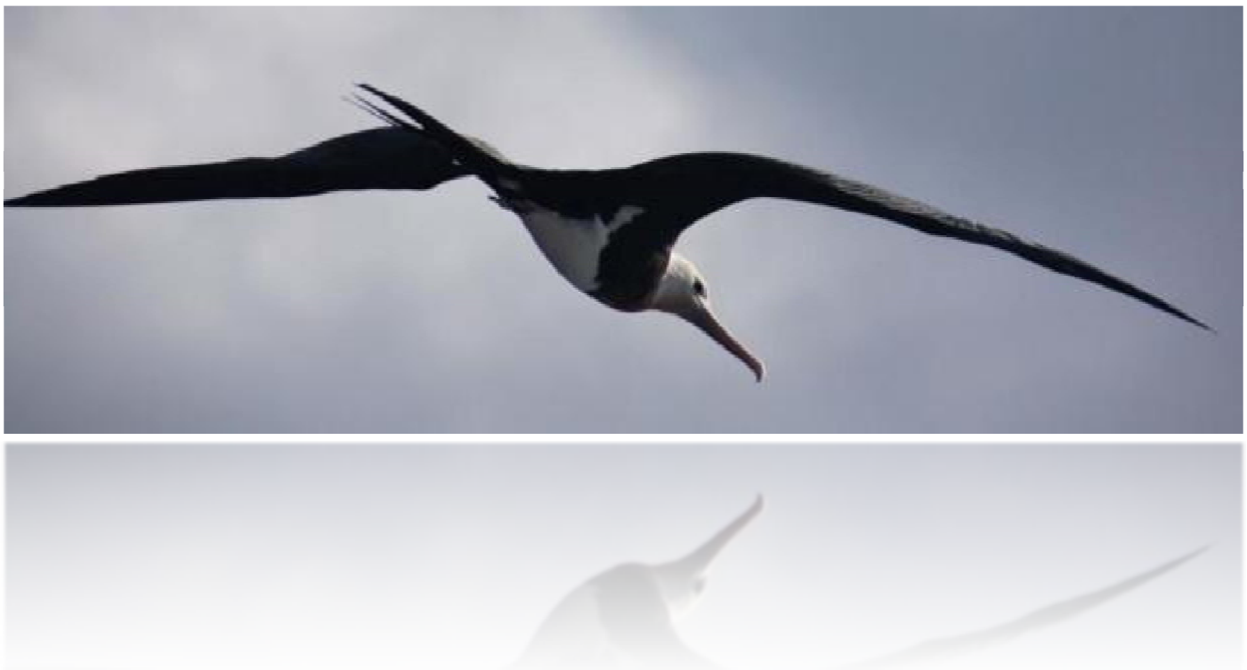
Sighting 21: Pygmy killer whales (Feresa attenuata) sighted on November 19, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 22: Bottlenose dolphins (Tursiops truncatus) sighted on November 22, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 24: Humpback whale (Megaptera novaeangliae) sighted on November 22, 2010, during the Koa Kai 11-1 vessel-based monitoring effort.

Sighting 122: Two of a pod of five false killer whales (Pseudorca crassidens) sighted on November 22, 2010, during the Koa Kai 11-1 aerial-based monitoring effort. Photo taken through the bubble window of a Robinson 44 helicopter.

APPENDIX C. Kaʻula / Kauaʻi Field Report, HRC Marine Species Monitoring, February 15-20, 2011



KAʻULA / KAUAʻI FIELD REPORT
HRC Marine Species Monitoring
February 15-20, 2011
Prepared for COMMANDER, U.S. PACIFIC FLEET
Morgan W. Richie and Justin Fujimoto

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List of acronyms and abbreviations

RHIB	Rigid hull inflatable boat
MMO	Marine mammal observer
CRC	Cascadia Research Collective
PMRF	Pacific Missile Range Facility
RIMPAC	Rim of the Pacific (Naval Exercise)
BSURE	Barking Sands Underwater Range Expansion
BARSTUR	Barking Sands Tactical Underwater Range
NMFS	National Marine Fisheries Service
HRC	Hawai‘i Range Complex
MFAS	Mid-frequency Active SONAR
CPF	Commander, U. S. Pacific Fleet
ASW	Anti-submarine Warfare

List of species abbreviations

MEGNO	Humpback whale
GLOMA	Long-finned pilot whale
STEBR	Rough toothed dolphin
STELO	Spinner dolphin
TURTR	Bottlenose dolphin
MONSC	Monk seal
WHALE	Unidentified large whale
DOLPH	Unidentified dolphin
UNID	Unidentified animal

SECTION 1 INTRODUCTION

The February 2011 cruise to Ka'ula was comprised two components: a dedicated seabird survey at the island of Ka'ula to satisfy Sikes Act monitoring requirements and a marine mammal visual survey and tagging effort at the island of Kaua'i and during the transit to Ka'ula in order to satisfy Commander, Pacific Fleet's marine mammal and sea turtle monitoring requirements. Relatively little research and monitoring has occurred at Ka'ula. A comprehensive list of all visitors to Ka'ula can be found in Table 1.

Table 1. Survey dates and personnel, Ka'ula Island, Hawaii 1932-2011.

Date	Agency	Survey personnel	Title
16-19 Aug 1932	University of Hawaii	Harold S. Palmer	Professor of Geology
	Hawaiian Sugar Planters' Experiment Station	Edward L. Caum	Botanist
17-18 Aug 1971	U.S. Navy	Gerald Swedberg	Natural Resources Specialist
		J.S. Elmer	Operations & Readiness Officer
		H.W. Mixter	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	Eugene Kridler	Wildlife Administrator
	Hawaii Dept of Land and Natural Resources	Ronald Walker	District Biologist
		David Woodside	Non-Game Biologist
		Thomas Telfer	Wildlife Biologist
		Richard Kaneyama	Aquatic Biologist
		Michael Fujimoto	Aquatic Biologist
		Ralph Daehler	District Forester
20-21 Jan 1976	U.S. Navy	Gerald Swedberg	Natural Resources Specialist
		Yoshito Doi	Photographer
		Scott Wood	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	Palmer Sekora	Refuge Manager
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Branch Chief
		David Woodside	Non-Game Biologist
		Thomas Telfer	Wildlife Biologist
		Kenji Ego	Fisheries Branch Chief
		Michael Fujimoto	Aquatic Biologist
		Ralph Daehler	District Forester

Date	Agency	Survey personnel	Title
14-15 Sep 1976	U.S. Navy	Gerald Swedberg	Natural Resources Specialist
		John Walter	Special Asst for Ecology
		Holden	Asst Operations Officer
		Unknown	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	Fred Zeillemaker	Biologist
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Branch Chief
		David Woodside	Non-Game Biologist
		Thomas Telfer	Wildlife Biologist
		Kenji Ego	Fisheries Branch Chief
		Henry Sakuda	Marine Section Chief
		Ralph Daehler	District Forester
		Robert Hommon	State Archaeologist
7 Mar 1978	U.S. Navy	Gerald Swedberg	Natural Resources Specialist
		C.C. Gage	Officer-in-Charge
		Phil Hinkle	Investigating Officer
		Becker	Public Affairs Officer
		Thomas Morrison	Legal Counsel
		Myers	Photographer
		Wykoff	Corpsman
	U.S. Fish and Wildlife Service	Eugene Kridler	Wildlife Administrator
		Kimberly Wright	Special Agent
	Hawaii Dept of Land and Natural Resources	Timothy Burr	Wildlife Biologist
21-22 Aug 1978	U.S. Navy	Gerald Swedberg	Natural Resources Specialist
		Unknown	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	John Sincock	Wildlife Biologist
		Darrell Herbst	Botanist
		James Bartee	Special Agent-in-Charge
	Natl Oceanic and Atmospheric Administration	Robert Iversen	Marine Biologist
		John Naughton	Marine Biologist

Date	Agency	Survey personnel	Title
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Branch Chief
		Thomas Telfer	Wildlife Biologist
		Ralph Daehler	District Forester
	University of Hawaii	Andrew Berger	Professor of Zoology
6-8 Mar 1979	U.S. Navy	Scott Hamilton	Environmental Protection Spec
		George Tullos	Air Operations
		Jay M. Davidson	Public Affairs Officer
		D. K. Mashayekhi	Medic
		Chas. J. Galbreath	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	Vernon Byrd	Wildlife Biologist
		Darrell Herbst	Botanist
	Natl Oceanic and Atmospheric Administration	Robert Iversen	Marine Biologist
		John Naughton	Marine Biologist
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Branch Chief
		Thomas Telfer	Wildlife Biologist
	University of Hawaii	George Balazs	HIMB Marine Biologist
		David Grooms	Geophysics Graduate Student
19-20 Jun 1980	U.S. Navy	Gerald Swedberg	Natural Resources Specialist
		Unknown	Unexploded Ordnance Escort
		Craig Swedberg	Assistant
	U.S. Fish and Wildlife Service	R. Shallenberger	Refuge Manager
	Natl Oceanic and Atmospheric Administration	Gene Nitta	Marine Biologist
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Branch Chief
		Thomas Telfer	District Wildlife Biologist
		Ralph Daehler	District Forester
	University of Hawaii	Michael Garcia	Geologist
	Honolulu Magazine	Victor Lipman	Writer

Date	Agency	Survey personnel	Title
16-18 Apr 1984	U.S. Navy	Unknown	U.S. Navy Representative
	U.S. Fish and Wildlife Service	Stewart Fefer	Wildlife Biologist
		Mark Rouzon	Wildlife Biologist
		Cameron Kepler	Wildlife Biologist
	Natl Oceanic and Atmospheric Administration	Gene Nitta	Marine Biologist
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Branch Chief
		Thomas Telfer	Wildlife Biologist
		Marie Morin	Wildlife Biologist
1-2 Jun 1993	U.S. Navy	Tim Sutterfield	Fish and Wildlife Biologist
		Mike Nahoopii	Kahoolawe Project Officer
		Ken	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	Scott Johnson	Wildlife Biologist
		Kathleen Viernes	Wildlife Biologist
	Hawaii Dept of Land and Natural Resources	Ronald Walker	Wildlife Program Manager
		Thomas Telfer	Wildlife Biologist
		Thomas Kaiakapu	Wildlife Biologist
	KITV	Gary Sprinkle	Reporter
		Sonny Ahuna	Cameraman
16-17 Nov 1998	U.S. Navy	Sean Cole	Unexploded Ordnance Escort
	U.S. Fish and Wildlife Service	Ronald Walker	Wildlife Biologist
	Hawaii Dept of Land and Natural Resources	Thomas Telfer	Branch Wildlife Manager
		David Smith	Branch Wildlife Manager
		Alan Silva	Wildlife Management Asst
18, 21 Jan 2009	Hawaii Aviation (civilian contractor for U.S. Navy)	Adam Townley-Wren	Pilot
		Peter Gonsalves	Photographer
20-24 Jul 2009 (Ship-based survey)	U.S. Navy	Vanessa Pepi	Supervisory Fish & Wildlife Biologist
		Anurag Kumar	Marine Resources Specialist
	U.S. Fish and Wildlife Service	Megan Laut	Fish and Wildlife Biologist
		Jiny Kim	Wildlife Biologist Student Trainee

Date	Agency	Survey personnel	Title
	Hawaii Dept of Land and Natural Resources and University of Hawaii	Jessica Hallman	Kauai Endangered Seabird Recovery Project Avian Technician
28 June 2010 (Ship-based survey)	U.S. Navy	Angela Anders, PhD	Wildlife Biologist
		Justin Fujimoto	Wildlife Biologist Intern
		Sean Hanser, PhD	Marine Natural Resource Management Specialist
		Robert Uyeyama, PhD	Marine Natural Resource Management Specialist
		Aaron Hebshi, PhD	Natural Resource Program Biologist
	U.S. Fish and Wildlife Service	Megan Laut	Fish and Wildlife Biologist
	Hawaii Dept of Land and Natural Resources	Jessica Hallman	Kauai Endangered Seabird Recovery Project Avian Technician
16 February 2011 (Ship-based survey)	U.S. Navy	Justin Fujimoto	Wildlife Biologist Intern
		Frans Juola, PhD	Wildlife Biologist
		Morgan Richie	Marine Natural Resource Management Specialist
	Cascadia Research Collective	Robin Baird, PhD	Marine Biologist
		Daniel Webster	Marine Biologist

1.1 Seabird monitoring background information

As part of the Department of Navy's Coastal Zone Management Act consistency determination of the Hawaii Range complex (HRC), the Navy reinitiated seabird population monitoring at Ka'ula Island in 2009. A seabird monitoring plan for Ka'ula Island was finalized in 2009, and ship-based seabird monitoring was conducted from July 2009 to the present. Monitoring will detect changes in seabird population on Ka'ula Island over time, while ensuring the maintenance of military readiness.

The first formal seabird survey at Ka'ula was conducted by E.L. Caum, Hawai'i Sugar Plantation Botanist and H.S. Palmer, University of Hawai'i Geologist. Bird species observed by Caum included 12 species of seabirds (two Procellariiformes species, five Pelecaniformes species, and five tern species) and two species of migratory shorebirds (Table 2). The next avian and botanical survey was not conducted until 1971, when biologist from the Navy, State, and Fish and Wildlife Services visited the island to assess the effects of munitions training exercises on nesting seabirds. Elmer and Swedberg noted that ordnance had reduced the training impact area on the southeastern tip of the island (approximately 8% of the island area) to rubble. There was no evidence of nesting by seabirds in the impact area (1971). A complete avian survey throughout the remaining 92% of the island indicated an estimated total of 98,022 individual birds of 19 species, including 15 seabird species, one migratory shorebird species, and three species of visiting landbirds (Table 2). The second complete avian survey conducted on Ka'ula took place in January 1976, outside of the breeding period for most central Pacific seabird species (DoN 1976a). The survey recoded the presence of approximately 3,521 individuals of 16 bird species, including black-footed and Laysan albatrosses (*Phoebastria immutabilis*). Although albatrosses, booby (*Sula*) species, and sooty terns *(Sterna fuscata*) nest during the month of January in the Hawaiian Archipelago, most of the other 12 seabird species observed on Ka'ula during previous (August) surveys would not have been actively nesting, and thus not necessarily present on the island at the time of the January 1976 survey. Eight additional avian surveys were conducted on Ka'ula Island by U.S. Navy, USFWS, and Hawai'i DLNR biologists from 1976 through 1998, with survey dates ranging from March through November (Table 2) (DoN 1976a; Walker 1979; DoN 1980; Walker 1983; Walker 1984; Walker 1993; Telfer 1998) months that span the peak breeding periods for the majority of central Pacific seabird species. No new seabird or shorebird species were observed during these later surveys. Throughout all of the avian surveys, a total of six landbird species have been observed, with only three identified from 1978 to 1998 (Table 2). From 2009 to 2010 two ship based surveys were conducted during the peak breeding season of central Pacific seabird species. No new species were recorded during these surveys.

Non-native barn owls have been recorded during multiple surveys on Ka'ula Island, with the species reported nesting on the island in 1979, 1980, 1984, and 1993 (Walker 1979; DoN 1980; Walker 1984; Walker 1993). During the 1993 survey, barn owl nests were located and the contents (eggs and chicks) were destroyed to prevent additional depredation on seabirds (Walker 1993).

Table 2. Results of land-based avian surveys conducted on Ka'ula Island, Hawai'i, 1932-1998

Common Name	Scientific Name	Aug 1932	Aug 1971	Jan 1976	Sep 1976	Mar 1978	Aug 1978	Mar 1979	Jun 1980	Apr 1984	Jun 1993	Nov 1998
Black-footed albatross	*Phoebastria nigripes*	1 old egg	-	100	-	75	-	75	-	2	4	10
Laysan Albatross	*Phoebastria immutabilis*	-	1 old egg	150	-	100	-	100	9	33	44	60
Wedge-tailed shearwater	*Puffinus pacificus*	many burrows	4,100	-	4,000	-	800	-	1,415	980	400	200
Christmas shearwater	*Puffinus nativitatis*	-	450	-	250	-	100	25	20	60	18	-
Bonin petrel	*Pterodroma hypoleuca*	1 chick	-	-	-	-	-	-	-	-	-	-
Bulwer's petrel	*Bulweria bulwerii*	several	100	-	100	-	50	-	100	580	100	-
Red-tailed tropicbird	*Phaethon rubricauda*	common	950	-	450	60	100	40	276	209	146	15
White-tailed tropicbird	*Phaethon lepturus*	-	3	1	1	-	1	2	-	-	-	1
Masked booby	*Sula dactylatra*	common	1,000	300	1,200	125	200	400	236	202	567	350
Brown booby	*Sula leucogaster*	common	1,700	50	1,000	75	60	200	212	169	397	60
Red-footed booby	*Sula sula*	uncommon	1,300	100	150	85	200	400	344	222	1,375	1,200
Great frigatebird	*Fregata minor*	common	950	250	800	400	250	250	134	155	701	650
Pacific golden plover	*Pluvialis fulva*	several	-	10	14	-	1	2	-	21	-	15
Ruddy turnstone	*Arenaria interpres*	-	50	5	20	-	4	24	1	7	1	12
Wandering tattler	*Heteroscelus incanus*	-	-	5	1	-	1	1	-	-	-	-
Gray-backed tern	*Sterna lunata*	uncommon	2,800	-	250	1,250	50	300	4,110	1,467	35	-
Sooty tern	*Sterna fuscata*	common	16,800	2,500	1,000	130,000	2,500	50,000	28,850	83,680	27,255	200
Blue-gray noddy	*Procelsterna cerulea*	small colony	-	-	200	-	-	-	-	-	-	1
Brown noddy	*Anous stolidus*	most numerous	67,700	-	7,000	7,000	10,000	1,000	10,560	3,950	5,778	-
Black noddy	*Anous minutus*	-	100	20	100	75	200	-	-	207	6	-
White tern	*Gygis alba*	uncommon	10	10	200	40	10	-	9	12	9	-
Barn owl	*Tyto alba*	-	1	3	3	-	1	6	4	2	7	3
Japanese white eye	*Zosterops japonicus*	-	-	2	3	-	-	-	-	-	3	-
House finch	*Carpodacus mexicanus*	-	6	15	40	-	20	6	-	1	1	8
Northern cardinal	*Cardinalus cardinalus*	-	2	-	7	-	-	-	-	-	-	-
Mockingbird	*Mimus polyglottos*	-	-	-	2	-	-	-	-	-	-	-
Nutmeg mannikin	*Lonchura punctulata*	-	-	-	20	-	-	-	-	-	-	-
Total estimated number of birds			98,022	3,521	16,811	139,285	14,548	52,831	46,280	91,959	36,847	2,785
Total number of species		**16**	**19**	**16**	**24**	**12**	**19**	**17**	**15**	**19**	**19**	**15**

1.2 Botanical survey history

The first formal biological surveys of Kaʻula Island were conducted in August 1932 (Caum 1936). E.L. Caum, a botanist with the Hawaiian Sugar Planters' Experiment Station, and H.S. Palmer, a professor of geology at the University of Hawaii, were provided access and transportation to Kaʻula by the U.S. Lighthouse Service (Caum 1936; Palmer 1936). Although Caum did not quantify the population sizes of the plant communities on Kaʻula, he provided complete species lists, including 15 plant species (Table 3) (Caum 1936). Caum indicated that plant cover was extensive across areas of the island where plants were able to grow, but that many areas of the island had no plant cover, and all species that occurred on the island were those that could tolerate arid conditions and strong winds. Four of the 15 plant species (27%) observed by Caum were species not native to Hawaii. The next botanical survey was not conducted until 1971, when biologists from the Navy, State, and the Fish and Wildlife Services visited the island to assess the effects of munitions training exercises on nesting seabirds. Elmer and Swedberg noted that ordnance had reduced the training impact area on the southeastern tip of the island (approximately 8% of the island area) to rubble (1971). The team also discovered three explosions outside of the impact area and evidence of one fire that may have been started by a flare (Elmer 1971). Two additional botanical surveys were conducted in 1976 and 1998. The 1976 survey by the U.S. Navy and USFWS, and Hawaii DNLR found 13 plant species not observed by Caum (1936). Of these, seven were species not native to Hawaii. During the 1998 survey, one new plant species, milo (*Thespesia populnea*), a plant introduced historically to Hawaii by Polynesians, was observed bringing the total number of plant species seen on Kaʻula to 30 (Table 3). Of these, 14 species (47%) are not native to Hawaii. Both the January 1976 and November 1998 botanical surveys reported an increase in the number of non-native plant species relative to those present in 1932 (DoN 1976a; Telfer 1998).

Table 3. Results of botanical surveys conducted on Kaʻula Island, Hawaii, 1932-1998[1]

Family	Common Name	Species Name	Origin	Caum 1932	DON 1976	Telfer 1998
Gramineae	'Ume'alu	*Cenchrus echinatus*	Introduced		x	x
	Swollen finger grass	*Chloris inflata*	Introduced		x	x
	Kukaipua'a	*Digitaria setigera*	Introduced		x	x
	Jungle rice	*Echinochola colonum*	Introduced		x	x
	Kakonakona	*Panicum torridum*	Endemic		x	x
	Bristly foxtail	*Setaria verticillata*	Introduced		x	x
		Panicum lanaiense (rcrded by Caum (1939) easy to mistake for *P. torridum*)	Introduced	x		

1 From Caum (1936), DON (1976a), and Telfer (1998). None of the species observed are listed under the U.S. Endangered Species Act.

Family	Common Name	Species Name	Origin	Caum 1932	DON 1976	Telfer 1998
Chenopodiaceae	Australian salt bust	*Atriplex semibaccata*	Introduced		x	x
	Alaweo	*Chenopodium oahuense* (formerly *Chenopodium sandwicheum*)	Endemic	x	x	x
Amaranthaceae	Slender amaranth	*Amaranthis viridis*	Introduced	x	x	x
Nyctaginaceae	Alena	*Boerhavia diffusa*	Indigenous	x	x	
Portulacaceae	'Ihi	*Portulaca lutea*	Indigenous	x	x	
	Purslane	*Portulaca oleracea*	Introduced	x	x	x
	'Ihi	*Portulaca villosa* (formerly *Portulaca caumii*)	Endemic	x	x	x
Capparaceae	Maiapilo	*Capparis sanwichiana*	Endemic	x	x	x
Leguminosae	Koa haole	*Leuceana leucocephala*	Introduced		x	x
Zygophyllaceae	Nohu	*Tribulus cistoides*	Indigenous	x	x	x
Euphorbiaceae	'Akoko	*Chamaesyce celastroides* (formerly *Euphorbia celastroides*)	Endemic	x	x	x
Malvaceae	'Ilima	*Sida fallax*	Indigenous	x	x	x
	Milo	*Thespesia populnea*	Polynesian Intro			x
Cactaceae	Pa nini	*Opuntia megacantha*	Introduced	x	x	
Plumbaginaceae	'Ilieo	*Plumbago zeylanica*	Indigenous		x	x
Convulvulaceae	Sweet koali 'ai	*Ipomoea carica*	Indigenous		x	x
	Koali 'awania	*Ipomoea congesta*	Indigenous		x	x
	Koali 'awa	*Ipomoea indica*	Indigenous	x		
Boraginaceae	Nena	*Heliotropium curassavicum*	Indigenous	x	x	x
Solanaceae	'Ohelo kai	*Lycium sandwicense*	Indigenous		x	x
	Popolo	*Solanum nigrum*	Indigenous	x	x	x
Asteraceae	Horseweed	*Erigeron canadensis*	Introduced		x	x
	Pualele	*Sonchus oleraceus*	Introduced		x	x
Total number of species				15	27	25

1.3 Marine mammal and sea turtle monitoring background information

In order to train with active sonar and explosives within the Hawaii Range Complex (HRC), the Navy has obtained a permit from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and Endangered Species Act. The Hawai'i Range Complex (HRC) Monitoring Plan, finalized in December 2008 for implementation in January 2009, and amended in 2010, was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting intends to provide science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy training.

Monitoring requirements in the HRC for fiscal year 11 include attempted deployment of 15 satellite tags and 120-160 hours of visual monitoring. In order to address the questions above, NAVFAC – Pacific, in cooperation with Cascadia Research Collective, and with funding from Commander, U.S. Pacific Fleet (CPF), conducted a cruise to Ka'ula Rock, Ni'ihau and Kaua'i in an effort to deploy satellite tags on odontocetes and rare mysticetes as well as conduct a visual survey. The cruise occured during the Submarine Commanders' Course which took place on the Pacific Missile Range Facility (PMRF) near Kaua'i from February 16 – 19, 2011. The primary goal of the cruise was to deploy satellite tags near the PMRF underwater ranges, Barking Sands Underwater Range Expansion (BSURE), Barking Sands Tactical Underwater Range (BARSTUR) and the Shallow Water Training Range, during an anti-submarine warfare (ASW) exercise in order to contribute knowledge regarding how odontocetes are using the range complex and whether they are exposed to MFAS. Additionally, MMOs recorded the time and location of all marine mammal and sea turtle sightings, except for humpback whales which were numerous.

Relatively little is known about the marine mammals of the western HRC (Baird 2011). Few marine mammal and sea turtle surveys have been conducted at Ka'ula and thus the area is not well characterized. Two National Oceanic and Atmospheric Administration (NOAA) marine mammal surveys not associated with the on-island plant and seabird surveys at Ka'ula Island have included the waters surrounding the island (Mobley et al., 2000; Baird et al., 2003). Both surveys recorded spinner dolphins (*Stenella longirostris*) and bottlenose dolphins (*Tursiops truncatus*). Additionally, marine mammals were recorded during a U.S. Navy seabird survey in 2009 (Pepi et al., 2009). Five biologists, including four seabird observers and one marine mammal observer, carried out the surveys. Four species of marine mammals were observed near Ka'ula Island, including three species of odontocetes and one species of pinniped. Bottlenose dolphins (*Tursiops truncatus*) and spinner dolphins (*Stenella longirostris*) were all sighted off of the northwest coast of the island within 820 ft (250 m) of the coastline. The spotted dolphins (*Stenella attenuata*) were sighted during transit to the survey area off of the southeast coast of Ka'ula within 4.9 miles (8 km) of the coastline. Hawaiian monk seals (*Monachus schauinslandi*) were observed hauled out on two separate ledges on the leeward (western) side of the island. During June 26-28, 2010 three U.S. Navy biologists conducted marine mammal and sea bird surveys in the waters between Kaua'i, Ni'ihau, and Ka'ula. A total of five marine mammal groups were sighted during the three days of observation (two additional sightings were made off-effort). Species sighted were *Tursiops truncatus*, *Stenella longirostris*, *Steno bredadensis*, and *Pseudorca crassidens* (Uyeyama 2010).

Research near the island of Kaua'i has been conducted by the contractor "Marine Mammal Research Consultants" under Navy funding. Both vessel and aerial surveys have been conducted as part of the North Pacific Acoustic Laboratory (NPAL) program as well a the Navy's monitoring program (Mobley 2005; Mobley 2006; Tiemann 2006). Tiemann 2006 was a combination of acoustic monitoring and aerial surveys at PMRF for detecting and tracking marine mammals on the hydrophone range. An acoustic and visual survey which included Kauaʻi and Niʻihau was conducted by CETOS Research Organization in 2005 (Norris 2005). Passive acoustic line transect surveys and fixed passive acoustic surveys were conducted at PMRF in 2010 in order to compare minke whale boings with other geographic locations, estimate the abundance of minke whales, and assess spatial distribution. The analyses of the results are on-going but preliminary results suggest that minke whale boings are sufficiently different to classify to location. Density estimates have been derived from both data sources but line transect data are undergoing a detailed review (Martin 2010; Norris 2010). Preliminary results from a Navy-funded Ecological Acoustic Recorder (EAR) in 800 meters of water on the northwest side of Niʻihau showed beaked whales, not surprisingly, echolocating at night. Beaked whales were present all year. Other odontocetes which were detected included pilot whales, Risso's dolphins, sperm whales, and Stenella species (Au 2011). Further diagnostics on the small odontocete detections should produce refinements in these results.

Research near the islands of Kauaʻi and Niʻihau has been conducted by scientists at CRC and has focused on tagging, photo-identification and biopsy sampling (Baird 2011). From 2003 – present, CRC has conducted small vessel surveys (Baird 2003; Baird 2006; Baird 2008a; Baird 2008b; Baird 2008c; Baird 2009; Baird 2011) in the western main Hawaiian Islands and identified the presence of some island-specific populations of rough-toothed dolphins and bottlenose dolphins (Baird 2008a; Baird 2009). In 2008, 33 medium-term satellite tags were affixed to 4 species of odontocetes, which allowed CRC the ability to examine animal movements before, during, and – in some cases – after RIMPAC. False killer whales, Blainville's beaked whales, and short-finned pilot whales remained associated with the Main Hawaiian Islands while the tags remained attached. Melon-headed whales moved west over 400 km away from the main Hawaiian Islands over the duration of the tag attachment (Baird 2008c). Recommendations from this 2008 report for future effort surrounding naval exercises will be reiterated in Section 3.7 of this report.

1.4 Regional background information

Kauaʻi, Niʻihau, and Kaʻula are the westernmost islands in the main Hawaiian Island archipelago (Figure 1). PMRF is the largest instrumented multi-environment test range in the world and includes land, sea, and air zones (Figure 2). The main base is at Barking Sands on Kauaʻi. Additionally, Niʻihau houses radar, optics, and electronic warfare facilities and Kaʻula is used for aircraft gunnery and inert ordnance target practice (DoN 2010).

1.4.1 Kauaʻi and Barking Sands background information

The largest and principle operation for PMRF is Barking Sands on the western shore of Kauaʻi. Barking Sands includes three underwater ranges: BSURE, BARSTUR, and the Shallow Water Training Range. BSURE is an area which extends north from the Kaʻulakahi Channel between Kauaʻi and Niʻihau and covers 2,279 square kilometers. BARSTUR is an area between and slightly to the north of the Kaʻulakahi Channel and covers 310 square kilometers (Figure 2) (DoN 2010). A deepwater canyon runs north to south in the channel between Niʻihau and Kauaʻi. Federally threatened, endangered and candidate marine species which are expected to occur in this area are Hawaiian monk seals, humpback whales, hawksbill sea turtles, green sea turtles, and false killer whales (candidate) (DoN 2010).

1.4.2 Niʻihau background information

Niʻihau is a privately owned island approximately 15 miles west of Kauaʻi, across the Kaʻulakahi Channel (Figure 1). The Navy leases land from the owners, the Robinson Family, for communications/electronics training activities, Perch Site and Optical Tracking Station, and Paniau Radar Site (DoN 2010).

1.4.3 Kaʻula Island background information

Kaʻula is a small uninhabited islet near the islands of Niʻihau and Kauaʻi in the Hawaiian Archipelago (Figure 1). It is located 20 nautical miles (37 kilometers [km]) west-southwest of Niʻihau and approximately 60 nautical miles (111 km) southwest of the Pacific Missile Range Facility (PMRF), Kauaʻi (Figure 2)(Elmer 1971). Kaʻula Island is a crescent shaped island of approximately 55 hectares. Approximately 9% of the island (4 hectares on the southern tip) is used to train aviators in air-to-surface inert weapons delivery. Past use has included military bombing and strafing training with live ordnance. As a result, unexploded ordnance is a hazard, and public access to the island is not permitted. Federally threatened and endangered marine species which are known to occur at Kaʻula include the Hawaiian monk seals, humpback whales, hawksbill sea turtles, and green sea turtles (DoN 2010). Additionally, false killer whales, which are ESA-candidate species, were sighted at Kaʻula by Navy biologists in 2010 (Uyeyama 2010).

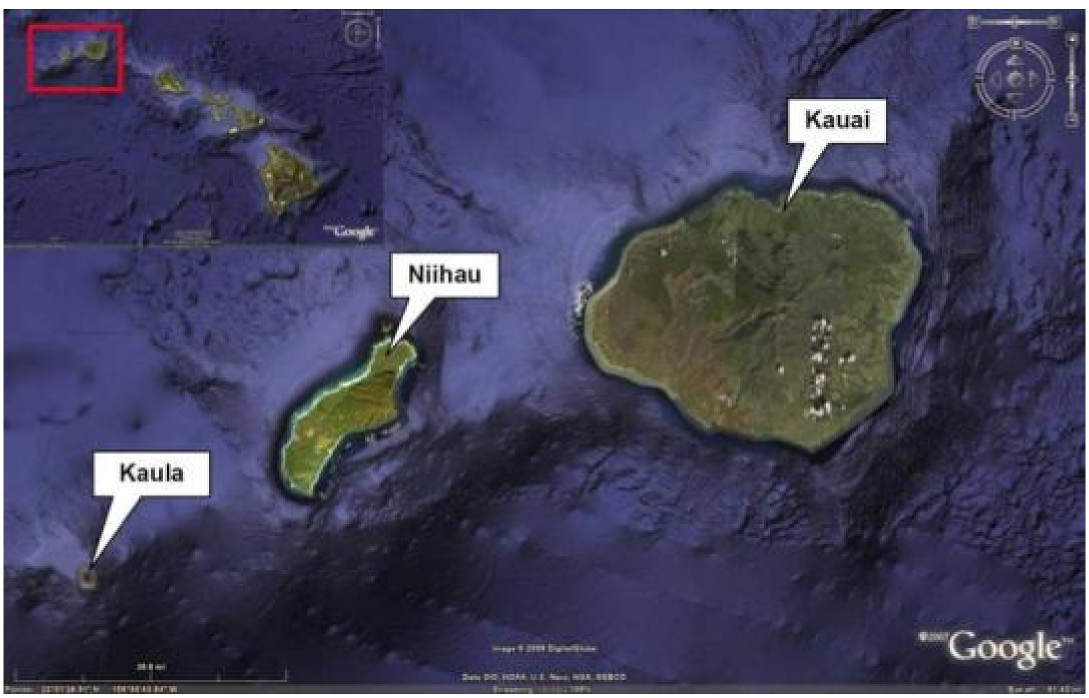

Figure 1. Location of Kaʻula, Niʻihau, and KauaʻI

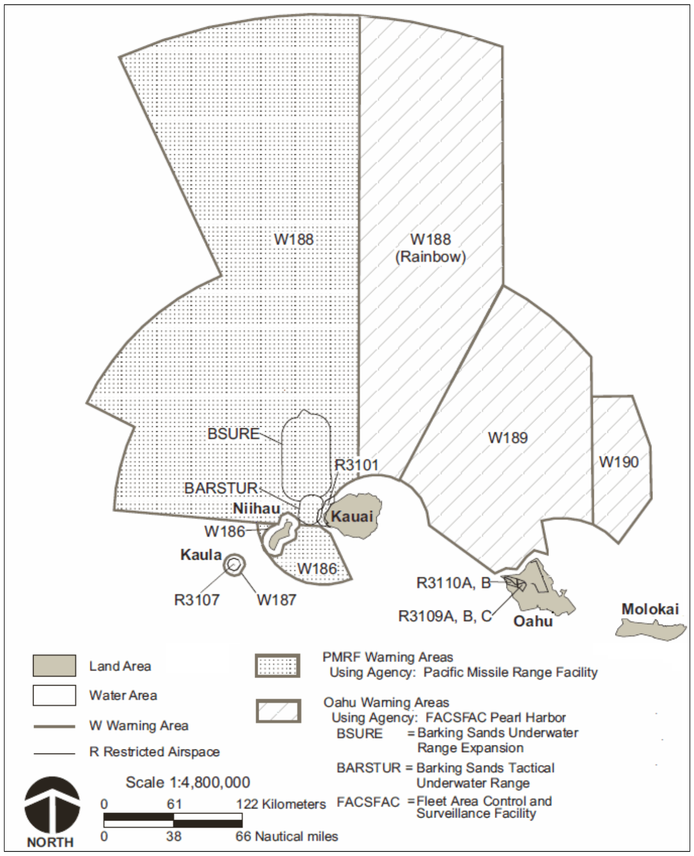

Figure 2. Location of the Pacific Missile Range Facility, BSURE, and BARSTUR

SECTION 2 SURVEY DESCRIPTION

2.1 Survey timeline

Date	Location	Description of survey	Team(s)
2/15/2011	Kauaʻi to Kaʻula	Transit at night	Navy bird biologists, Navy marine mammal biologists, Cascadia Research Collective
2/16/2011	Kaʻula, Niʻihau, Kauaʻi	Kaʻula bird survey, Kaʻula marine mammal survey, transit to Kauaʻi along the north side of Niʻihau	Navy bird biologists, Navy marine mammal biologists,
2/17/2011	Kauaʻi	Marine mammal observation and tagging on the north western side of Kauaʻi	Navy marine mammal biologists, Cascadia Research Collective
2/18/2011	Kauaʻi	Marine mammal observation and tagging on the north western side of Kauaʻi	Navy marine mammal biologists, Cascadia Research Collective

Date	Location	Description of survey	Team(s)
2/19/2011	Kauaʻi	Marine mammal observation and tagging on the north western side of Kauaʻi	Navy marine mammal biologists, Cascadia Research Collective, HDR aerial surveyors
2/20/2011	Kauaʻi and Kaʻulakahi Channel	Marine mammal observation and tagging on the north western side of Kauaʻi, transit to Port Allen from the north side of Kauaʻi	Navy marine mammal biologists, Cascadia Research Collective

2.2 Description of platforms and teams

Three platforms were used for the sea bird and marine mammal field effort during February 15-20, 2011. The main platform was the 96-foot research vessel *Searcher (*Figure 3). *Searcher* is owned and operated by the Medical Foundation for the Study of the Environment. The upper deck of the *Searcher* is outfitted as an observation deck where observers were stationed (Figure 4). For marine mammal tagging, *Searcher* also launched the 15 foot inflatable RHIB and secured it on the back deck for transport (Figure 5). The bird survey team consisted of Justin Fujimoto of NAVFAC- Pacific, Dr. Frans Juola of NAVFAC- Pacific, and Morgan Richie of NAVFAC- Pacific. The MMO team on the *Searcher* consisted of Dr. Sean Hanser of NAVFAC-Pacific, Morgan Richie of NAVFAC-Pacific, and Michele Bane of the Kauaʻi Marine Mammal Response Program, NOAA. The RHIB team consisted of Dr. Robin Baird of CRC, Daniel Webster of CRC, and Jessica Aschettino of CRC.

Figure 3. Marine mammal Observer Morgan Richie photographing a pilot whale from the bow of the R/V Searcher

Figure 4. MMOs Michele Bane and Sean Hanser on the R/V Searcher observation deck.

Figure 5. CRC Tagging crew (Dr. Robin Baird, Daniel Webster, and JEssica Aschettino) aboard the 15-foot inflatable RHIB.

A 15-foot inflatable RHIB was provided to CRC in order to allow the tagging crew to operate independently from the *Searcher*. Upon arrival to the leeward side of Kaua'i, the RHIB was launched. Due to good weather, the RHIB was able to stay in the water the entire field period and tied up at night alongside *Searcher*.

One aerial survey day was used for the purpose of spotting animals for tagging. The aircraft used was an FAA part-135 certified Rockwell Aero Commander 5005, which features dual engines and an above-wing configuration (Figure 6).

Figure 6. Rockwell Aero Commander 500S Aircraft

The aircraft flew a grid pattern over the study area and enabled *Searcher* and the RHIB to respond to three cetacean sightings. The aircraft crew consisted of Dr. Joe Mobley and Lenisa Blair of HDR.

SECTION 3 SEABIRD SURVEY

3.1 Methods

On 16 February, five biologists, including three from the U.S. Navy, and two from Cascadia Research Collective, conducted seabird surveys at Ka'ula Island from the Motor Vessel *Searcher*. Three of these people had previous experience conducting off-shore seabird surveys, and a fourth was a seabird biologist.

The M/V *Searcher* departed Port Allen, Kaua'i , on the evening of 15 February and arrived at Ka'ula Island on 16 February at 08:00. The ship circumnavigated Ka'ula Island two times at approximately 2 to 4 knots, maintaining a distance of approximately 750 ft (228 m) from the coastline. The island was divided into north, northwest, southwest, and east quadrants, with section boundaries defined by the island's terrain (Figure 7). Each observer was assigned one or two species and identified birds using 7x50 hand-held binoculars. The two white booby species (masked boobies and red-footed boobies) were difficult to distinguish from the distance of the observation deck, such that these two species were combined during the survey. Seabirds were counted on land and in the air. For all species, the mean and standard deviation of counts from the first and second circumnavigations were calculated and relative abundance was compared to results of surveys from previous years (Figure 10). A list of all seabird species observed between Ka'ula Island and Ni'ihau was also compiled during the survey.

3.2 Results

During the surveys of Ka'ula Island, a total of six seabird species were observed for the M/V *Searcher* (Table 4). These included five Procellariiformes species (brown boobies (*Sula leucogaster*), red-footed boobies (*Sula sula rubripes*), masked boobies (*Sula dactylatra*), Laysan albatross (*Phoebastria immutabilis*), and great frigatebirds (*Fregata minor*)) and one tern species (sooty tern (*Sterma fuscata*)). All species observed in 2011 had been observed during the 1932-2010 surveys (no new seabird species were observed in 2011). Masked and red-footed boobies were present in the greatest numbers, followed by sooty terns, and great frigatebirds. Masked and red-footed boobies were observed primarily on the east side of the island, in stream-carved ravines. Sooty terns were observed on the upper slopes of the northwest side of the island, circling the island in a large cloud (Figure 8). Great frigatebirds were seen roosting and flying above the eastern side of the island. Relatively few seabirds were seen on the southeastern tip (1000ft) of the island used by the Navy as a munitions training target (Figure 9).

Complete counts of individual birds across the entire island were not possible from the observation deck of the ship, as all individual birds across the top of the island may not have been visible and some species present may not have been seen from the ship, including Christmas shearwaters and other nocturnal Procellariiformes, migratory shorebirds, and visiting landbirds. Therefore, a complete species list and estimates of the numbers of individuals of each species observed are not directly comparable to results of past land-based seabird surveys. However, relative abundance of the species seen in 2011 can be compared to survey results from past years. Figure 10 indicates the relative abundance of species observed during the surveys of November 1998, April 1984, and March 1979. During all four survey years, sooty terns were the most abundant species observed. Relative abundance of red-footed and masked boobies was also observed in relatively greater numbers in 1998 and 2011. Differences in seabird abundances between these years are likely due to differences in survey methods. The 1998, 1984, and 1979 surveys were land-based surveys compared to the sea-based survey in 2011.

In terms of absolute species abundance during the 2011 surveys, 665 masked and red-footed boobies were estimated to be in Ka'ula Island (Figure 10). This number is lower than the numbers detected in November 1998 (1,550). Typically, the species lay eggs in the winter months, therefore higher numbers are expected at this time. The Laysan albatross also nests during the winter. In 2011, the lowest number of laysan albatrosses (8) was observed, compared to 1998 (60), 1984 (33), and 1979 (100). The close resemblance of laysan albatrosses to red-footed or masked boobies from a ship at this distance could account for the low number of albatross detections in 2011 compared to the land-based surveys in previous years.

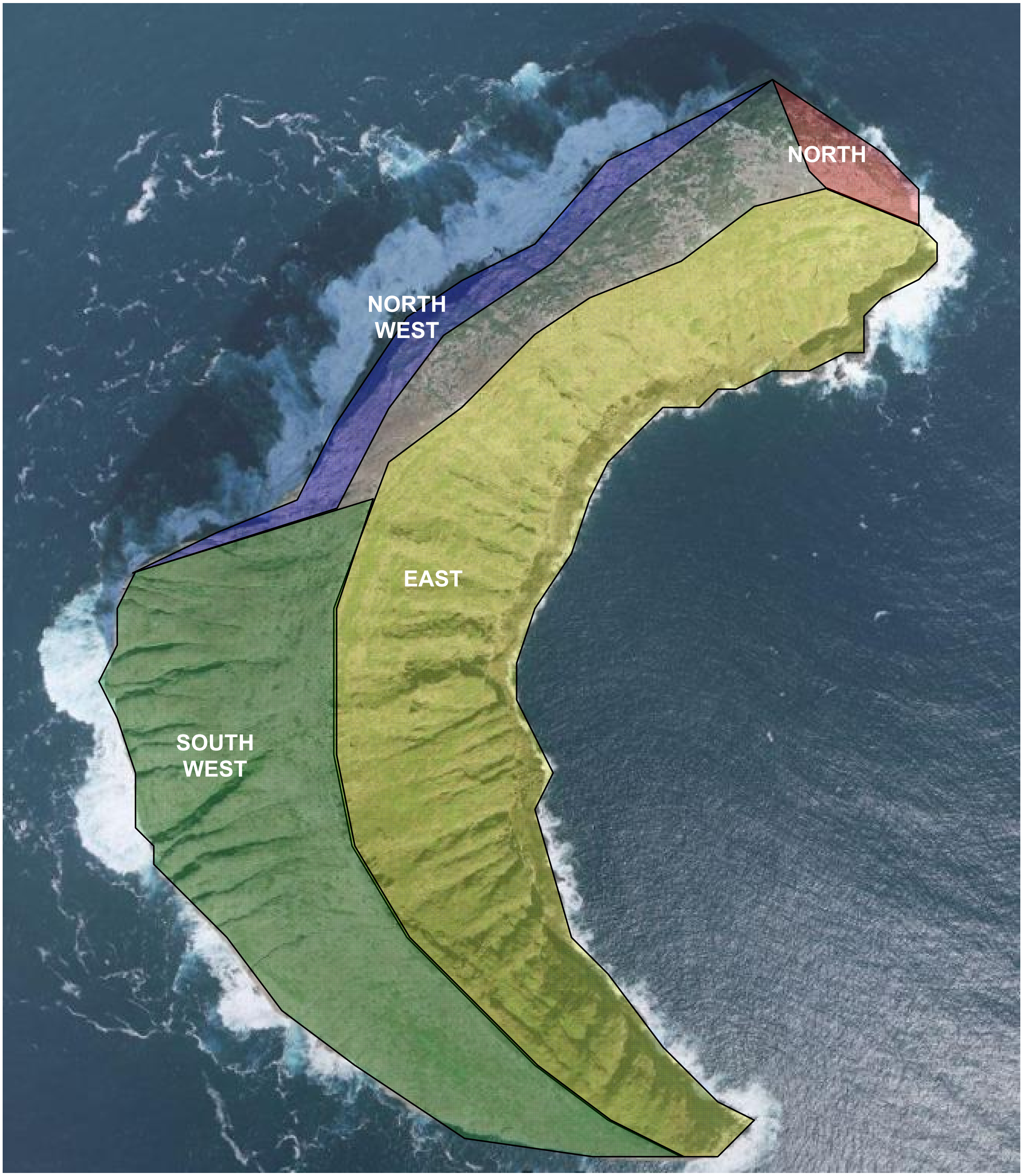

Figure 7. Survey quadrants defined on Ka'ula Island for the 16 February 2011 seabird surveys.

Figure 8. Sooty terns (Sterna fuscata) flying and masked or red-footed boobies (Sula dactylatra, S. Sula) nesting on the ground, northwest side of Ka'ula Island, 16 February 2011

Figure 9. Munitions training target area at southeastern end of Ka'ula Island, 16 February 2011. No birds were observed nesting in this area.

Table 4. Seabird species observed, and the means, standard deviations, and ranges of numbers of individuals counted at Ka'ula Island during the June 2010 and February 2011 ship-based surveys.

Common name	Scientific name	Jun-10				Feb-11			
		Mean # observed	Standard deviation	Minimum	Maximum	Mean # observed	Standard deviation	Minimum	Maximum
Wedge-tailed shearwater	*Puffinus pacificus*	**0**	0	0	0	**0**	0	0	0
Bulwer's petrel	*Bulweria bulwerii*	**1**	1	0	1	**0**	0	0	0
Red-tailed tropicbird	*Phaethon rubricauda*	**3**	1	2	3	**0**	0	0	0
Masked /red-footed booby	*Sula dactylatra, S. sula*	**850**	67	775	907	**665**	0	654	704
Brown booby	*Sula leucogaster*	**1**	1	0	1	**1**	1	0	2
Great frigatebird	*Fregata minor*	**430**	28	410	450	**110**	285	67	154
Gray-backed tern	*Sterna lunata*	**3**	3	1	5	**0**	0	0	0
Sooty tern	*Sterna fuscata*	**3,382**	663	2,913	3,851	**477**	290	272	683
Brown noddy	*Anous stolidus*	**705**	78	649	760	**0**	0	0	0
White tern	*Gygis alba*	**9**	9	2	15	**0**	0	0	0
Blue noddy	*Procelsterna cerulea*	**1**	1	0	2	**0**	0	0	0
Totals		**5,385**	**--**	**4,752**	**5,995**	**1,253**	**--**	**993**	**1,543**

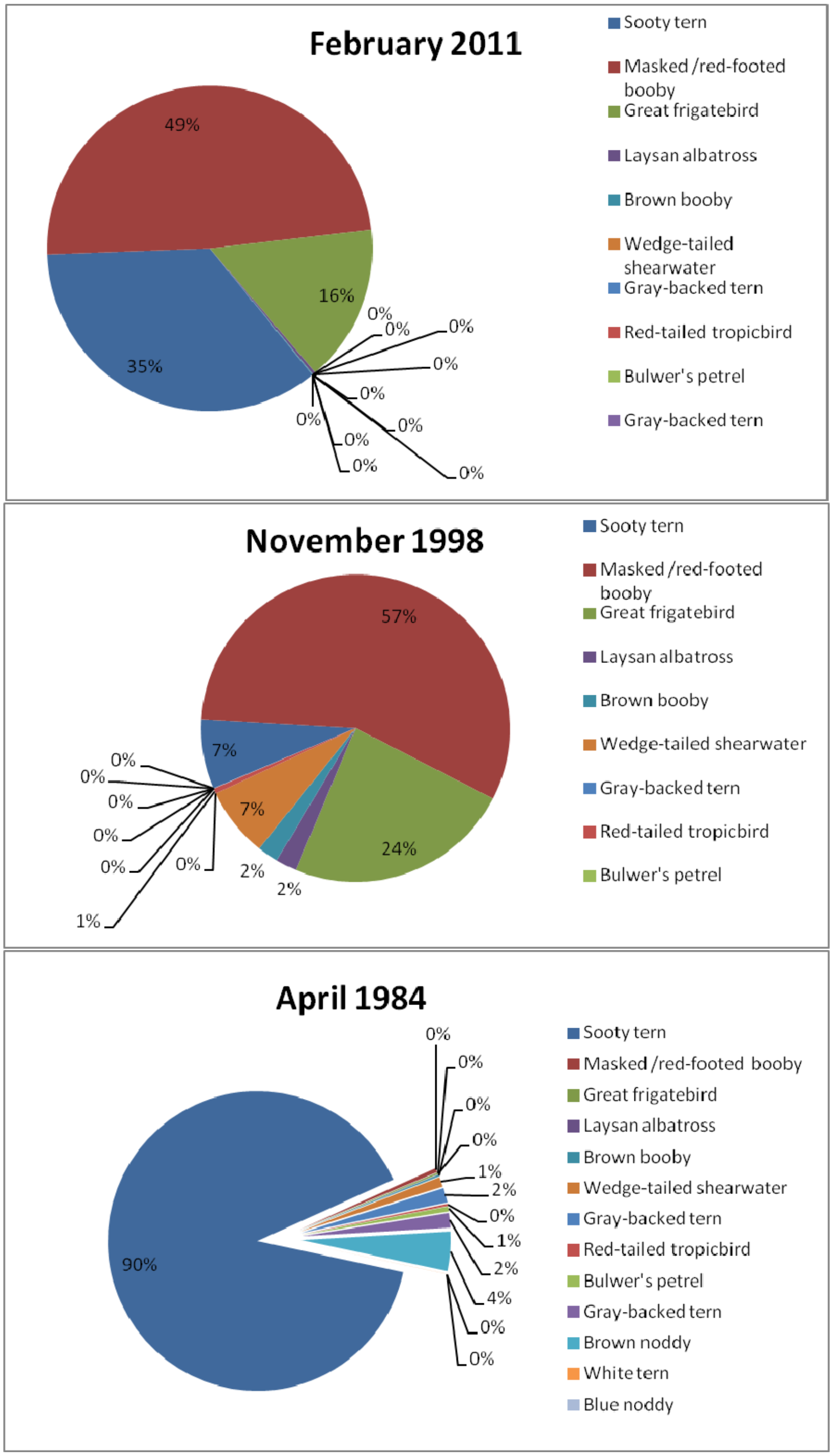

Figure 10. Relative abundance of seabirds observed during the February 2011, November 1998, April 1984, and March 1979 Ka'ula Island surveys. The February 2011 survey was conducted from a ship platform, while the 1998 to 1979 surveys were conducted on land.

The numbers of red-footed and masked boobies as well as great frigatebirds detected in 2011 were similar to those seen during ground surveys in 1998 and 1984. The lack of shearwater and petrel observations during the 2011 survey is likely due to the fact that these burrow-dwelling species are smaller and nocturnal, making them difficult to observe during the day from offshore. Brown boobies were observed in substantially low number compared to other winter survey dates, again this is likely due to problems with detection from offshore.

3.3 Conclusion

This survey provided the first ship-based observations of seabird attendance on Kaʻula Island during the winter. Six previous surveys were conducted during the winter/spring season, but were land-based surveys, providing more accurate species counts.

Identifying and counting certain species of birds was difficult during this survey due to rough ocean conditions and the distance from the island that the survey was conducted from. During the survey, any white booby (red-footed or masked) was grouped together into one species count. It's possible that some of the birds counted here may have been Laysan albatrosses because of the similarity and color and general difficulty in differentiating these species from offshore. As a result, relatively few Laysan albatrosses were observed during this survey as compared to surveys in previous years.

SECTION 4 MARINE MAMMAL SURVEY AND TAGGING

4.1 Methods

The primary goal of the marine mammal component of the cruise was to deploy as many satellite tags as possible on odontocetes and rare mysticetes in waters near BSURE and BARSTUR. Data collection protocols were a mix of both established and novel methods. The survey, in general, followed Dr. Robin Baird's established non-random, non-systematic protocols which have been developed to be successful in tropical, low density ecosystems (Baird 2008a). A novel protocol was tested in which the MMO team on the *Searcher* worked in conjunction with the tagging team on the RHIB in order to locate animals, collect photographs, and deploy satellite tags. Vessel based survey effort covered a total of 872.82 kilometers over 60 hours and 13 minutes. Vessel tracklines are found in Figure 11. Additionally, on 19 February 2011, the teams on the *Searcher* and RHIB worked in conjunction with the spotter aircraft, which flew a saw tooth grid over the north side of Kauaʻi and alerted the surface vessels to the presence of species of interest (Figure 12). When animals were sighted from the aircraft, the *Searcher* crew was notified immediately using standard text messages on cell phone, and the information was subsequently relayed to the RHIB crew via VHF radio. Vessel and aircraft movements were coordinated at the discretion of Dr. Baird and the MMO crew depending upon the circumstances. Aircraft crew data collection methods followed standard protocols used by Dr. Mobley for other Navy aerial surveys.

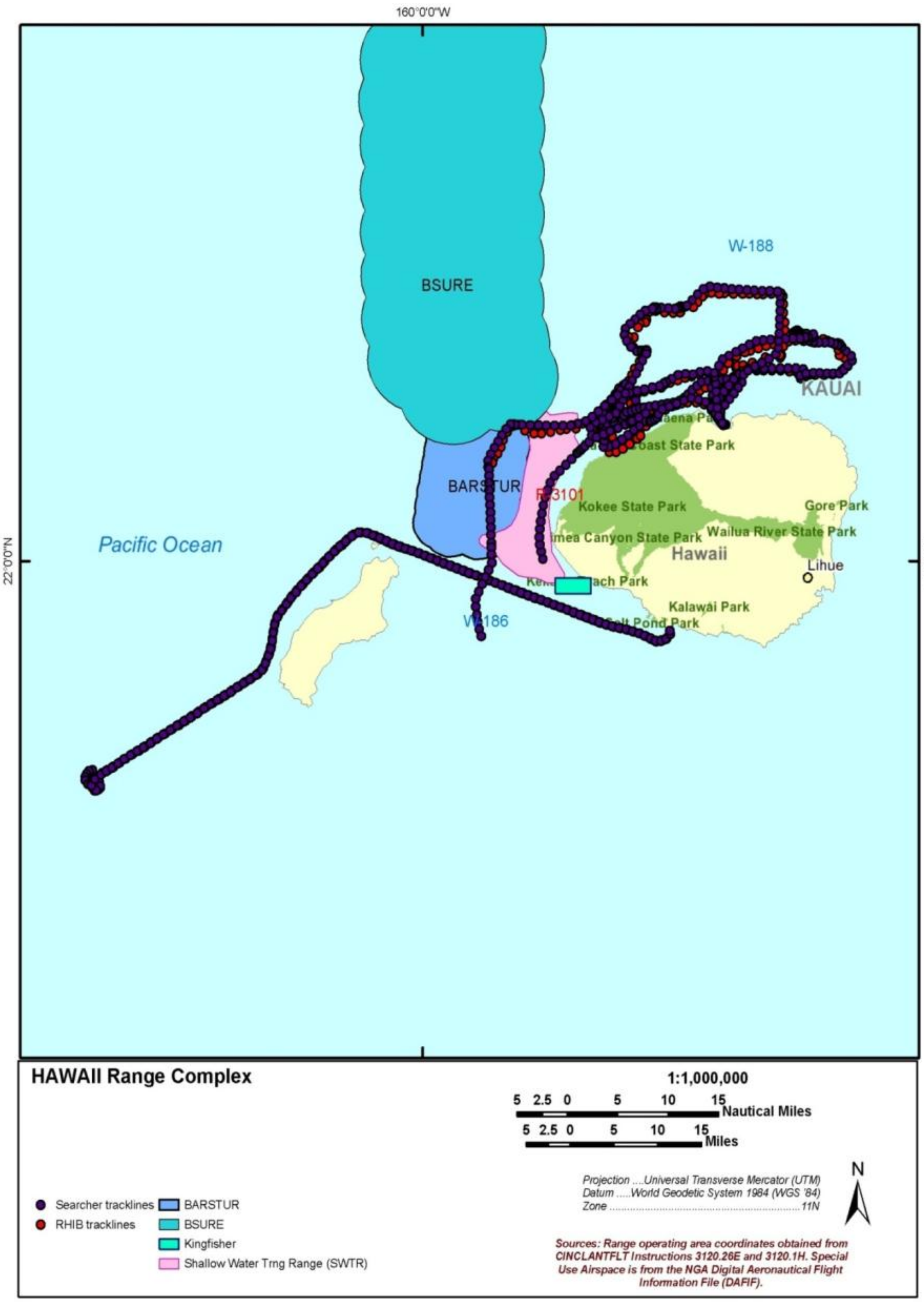

Figure 11. Track lines from Searcher and RHIB in Relation to BSURE and BARSTUR

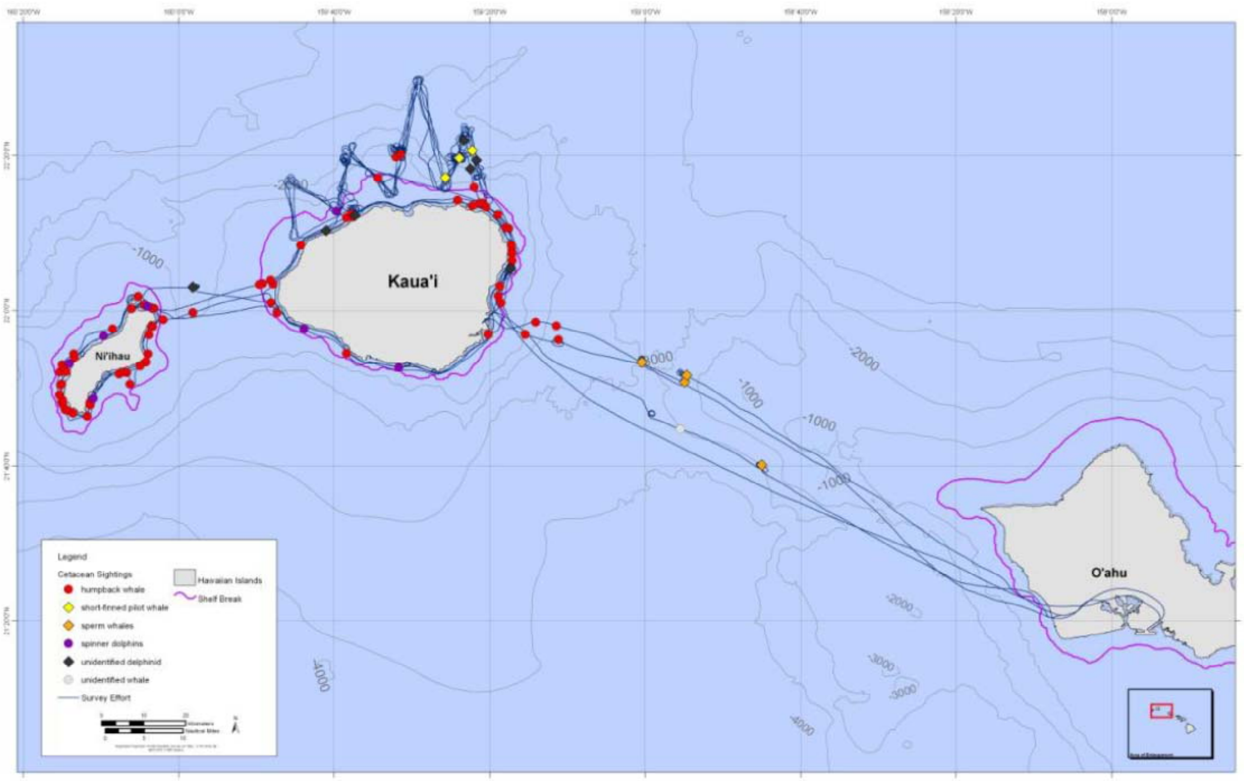

Figure 12. Aerial survey track lines during aerial support of Cascadia tagging effort on Feb. 19, 2011 (Mobley 2011)2.

Both the MMOs on the *Searcher* and the crew on the RHIB surveyed for animals while underway. The RHIB was always within visual contact of the *Searcher* crew for safety. If animals were sighted, waypoints were taken by the crew on board the sighting vessel and location information was conveyed to the other vessel. Both the crew of the *Searcher* and the crew of the RHIB recorded waypoints upon making a sighting, even if it was determined that the sightings were the same. When necessary, an MMO from the *Searcher* observation deck would then go to the bow sprit, where they would be better able to collect identifying photographs. Turtles and monk seals were recorded, but humpback whales were not recorded so as to not detract from the focus of the cruise. No turtles were seen during the effort.

2 A summary of aerial sightings of sea turtles and marine mammal during this effort can be found in Mobley, J. R. (2011). Aerial survey monitoring for marine mammals and sea turtles in the Hawaii Range Complex in Conjunciton with two Navy Training Events. SCC Februrary 16-March 5, 2011 DRAFT Field Report. Submittted by HDR to NAVFAC-Pacific under Contract No. N62470-10-D-3011 KB07.

4.1.1 Summary of effort

Date	*Searcher* hours of effort and transect length		RHIB hours of effort and transect length		Aircraft hours of effort		TOTALS	
	(hh:mm)	(km)	(hh:mm)	(km)	(hh:mm)	(km)	(hh:mm)	(km)
2/16/2011	5:49	139.0					**5:49**	**139.0**
2/17/2011	7:20	97.0	5:31	103.8			**12:51**	**200.8**
2/18/2011	7:37	87.9	7:36	81.8			**15:13**	**169.7**
2/19/2011	8:26	115.0	8:36	120.0	6:36		**17:02**	
2/20/2011	5:30	69.8	3:47	58.5			**9:17**	**128.3**
TOTALS	**34:42**	**508.72**	**25:30**	**364.1**	**6:36**		**60:12**	

4.1.2 Summary of environmental data

Weather was exceptionally good for this time of year and enabled the vessels to work in deep water during the morning hours. The sea state was a Beaufort 1 for approximately 7% of on-effort time, a Beaufort 2 for approximately 47% of on-effort time and a Beaufort 3 for approximately 26% of on-effort time (Figure 13).

4.2 Results

4.2.1 Summary of sightings

During the circumnavigation of Ka'ula Island and the transit past Ni'ihau to Kaua'i, 39 sightings of an estimated 78 humpbacks were made. This portion of the cruise is the only time in which humpbacks whales were counted so as to focus our attention on tagging odontocetes or rare mysticetes. The RHIB was not launched this day due to weather. Notable sightings were the in-water monk seal sighting at Ka'ula Islet and the off-effort sighting of 2 bottlenose dolphins near Lehua (Figure 14; Table 5). During the effort at Kaua'i, species sighted were *Steno bredanensis, Globicephala macrorhynchus, Tursiops truncatus, Stenella longirostris*, and unidentified dolphins (Tables 6, 7, and 8; Figures 15, 16, and 17).

4.2.2 Satellite tag track lines

Three tags were deployed on 3 Globicephala macrorhynchus (Figure 18). Top: GmTag49 tagged 18 February 2011, showing 30.9 days of movements. Middle: GmTag50 tagged 18 February 2011, showing 36.8 days of movements. Bottom: GmTag51 tagged 19 February 2011, showing 37.1 days of movements. Dotted lines connect consecutive locations but do not necessarily reflect travel routes (text taken directly from (Baird 2011).

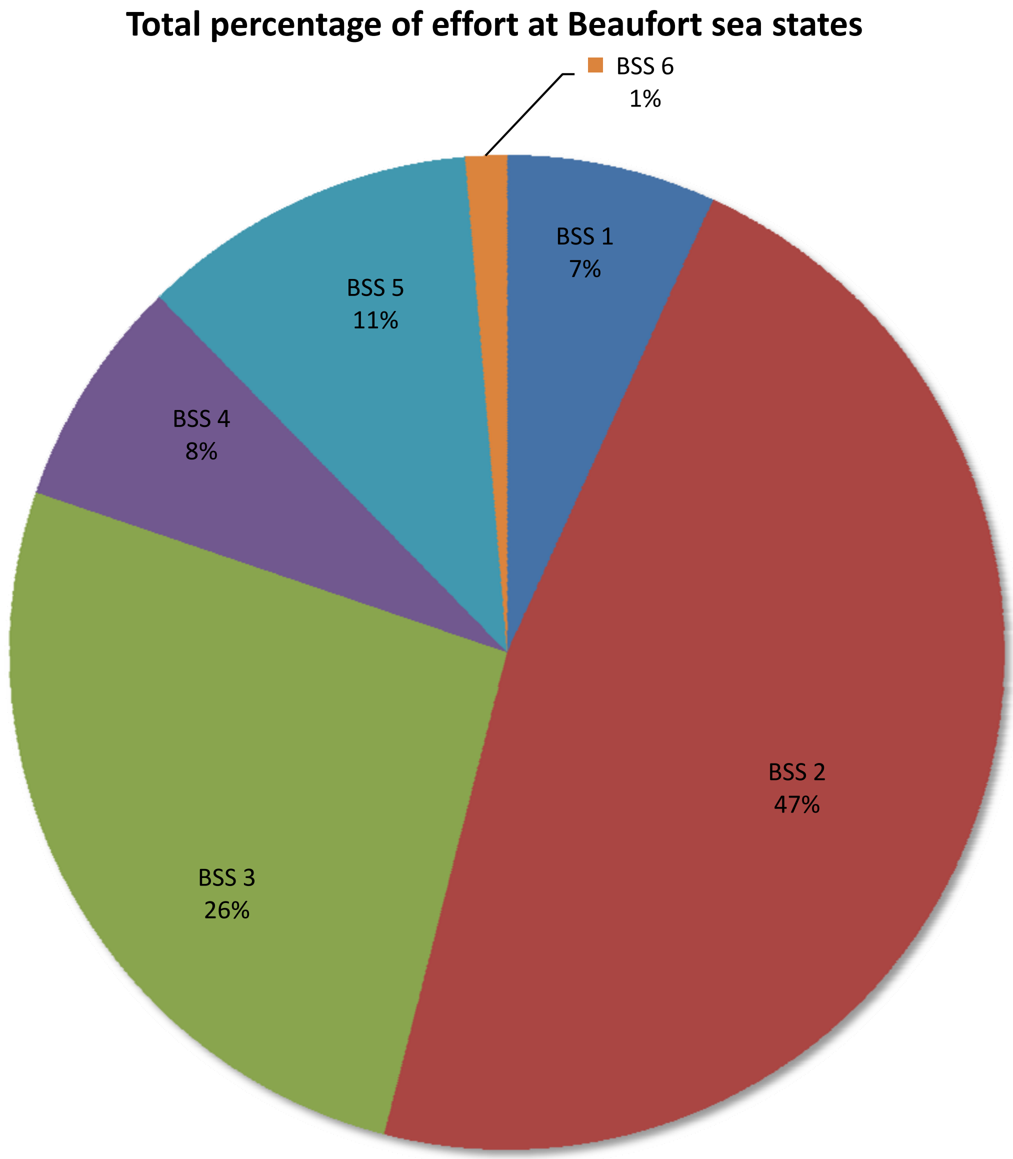

Figure 13. Total percentage of effort at Beaufort Sea states (BSS) based on Searcher data

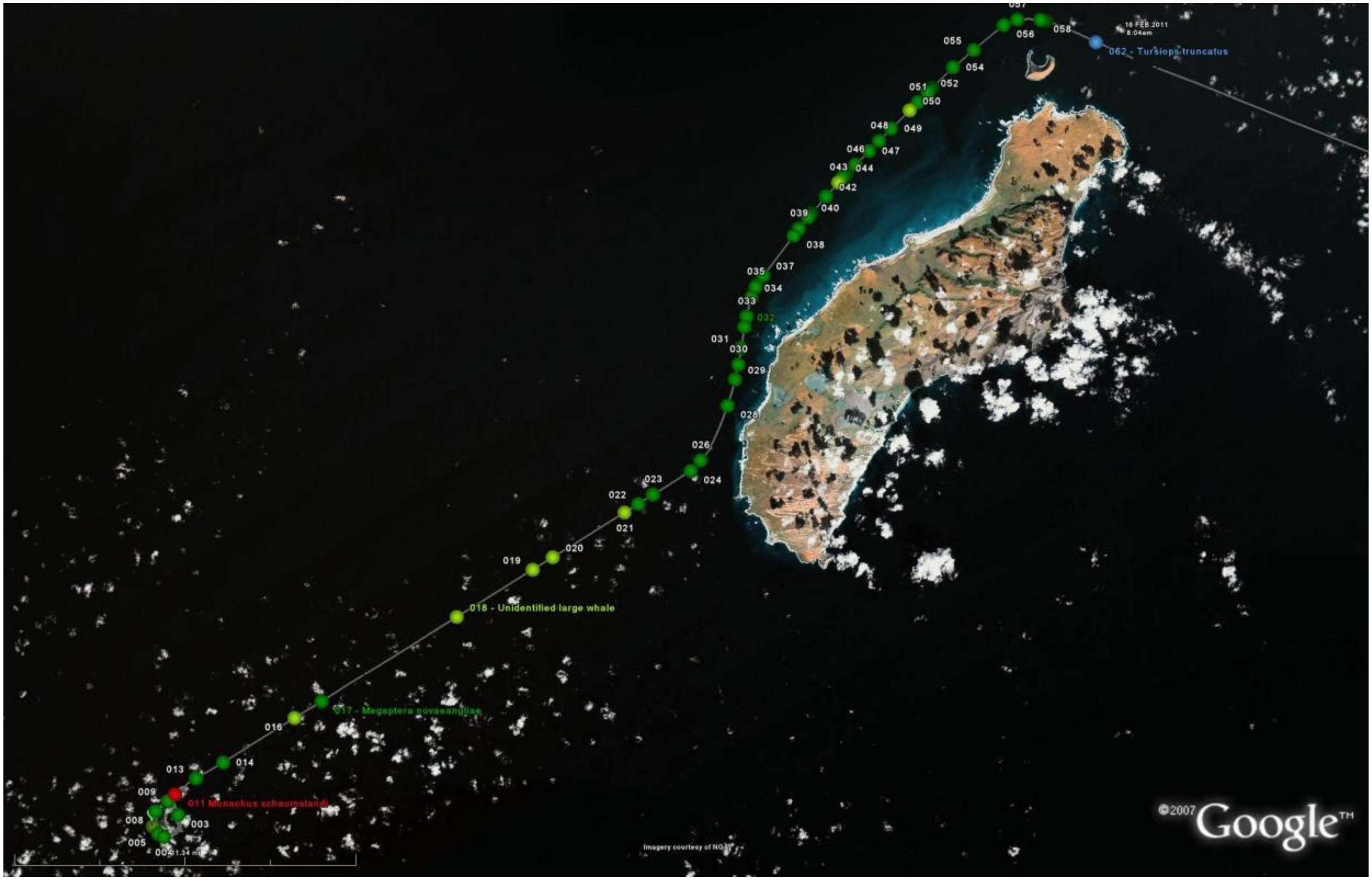

Figure 14. Sightings made from the Searcher on 02/16/2011. Ka'ula is at the lower left and Ni'ihau is at the upper right.

Table 5. Summary of marine mammal sightings for 2/17/11

Searcher[3]						RHIB							
Sighting #	Species	Time	Location	BSS	Notes	Sighting #	Species	Time	Location	BSS	Group size	Tags	Notes
Off effort	MONSC	Approx 1000	21.66629 160.53642										
Off effort	TURTR	14:20	22.03378 160.06653										
1	STEBR	10:56	22.21020 159.69650	2		1	STEBR	11:00	22.41919 159.69426	2	2/2/3		MEGNO present, 2 bowriders
2	STEBR	11:31	22.22580 159.68653	2	2 bowriders, approach from 200 m / 1-2 more joined	2	STEBR	11:33	22.23563 159.67789	2	10/12/14		

3 Sightings recorded by *Searcher* MMOs, RHIB, and aircraft are not independent.

Table 6. Summary of marine mammal sightings for 2/18/2011

Searcher						RHIB							
Sighting #	Species	Time	Location	BSS	Notes	Sighting #	Species	Time	Location	BSS	Group size	Tags	Notes
1	STEBR	08:54	22.29083 159.36655	2	MEGNO present, same group as RHIB	1	MEGNO	08:34	22.28856 159.37959	1			
2	STEBR	09:50	22.33385 159.31042	3	1 bowrider, then 3 more bowriders	2	STEBR	08:34	22.28856 159.37959	1	4/4/5		2 bowriders
3	GLOMA	10:58	22.35338 159.38482	2	15-17 animals, interacting with MEGNO, STEBR bowriding	3	STEBR	09:57	22.33635 159.31201	3	5/5/6		2 bowriders
4	DOLPH	14:21	22.24487 159.52267	3	Likely TURTR or STEBR	4	STEBR	10:31	22.34114 159.35486	2	5/5/5		2 mom/juvenile pairs
						5	STEBR	10:59	22.34813 159.38506	1	3/3/3		Playing with fishing net on dorsal, mixed in with GLOMA
						6	GLOMA	11:02	22.35382 159.38597	1	18/19/21	Tag# 102470 on adult male Tag #98358 on adult male	Mixed in with STEBR, 5 adult males

Table 7. Summary of marine mammal sightings for 2/19/2011

Aircraft				Searcher						RHIB							
Sighting#	Species	Time	Location	Sighting#	Species	Time	Location	BSS	Notes	Sighting#	Species	Time	Location	BSS	Group size	Tags	Notes
54	DOLPH	07:58	22.30763 159.3756	1	UNID	07:54	22.28697 159.48317	2	Unidentified splashing	1	GLOMA	08:14	22.31963 159.40729	2	8/8/8		Same GLOMA as yesterday, did not approach to determine max group size
8	GLOMA	08:07	22.3276 159.3960	2	GLOMA	08:22	22.31415 159.42752		Plane brought us to them, same GLOMA as yesterday	2	STEBR	10:49	22.38999 159.6143	2	16/18/22		8 bowriders
13	GLOMA	13:39	22.3445 159.3710	3	WHALE	10:17	22.39318 159.61270	3		3	GLOMA	12:02	22.3255 159.6378	2	16/16/18	# 102469 on small adult male	Associated with MEGNO
14	DOLPH	13:42	22.36632 159.3890	4	STEBR	10:48	22.39318 159.61270	2	Estimated 7 animals	4	MEGNO[5]	12:02	22.3255 159.6378	2			
15	STELO	14:20	22.21398 159.6618	5	GLOMA	11:51	22.39517 159.56568	2	Spyhopping is cue, with MEGNO	5	STELO	14:30	22.21468 159.62434	1	45/55/65		1 with remora
16	GLOMA	15:28	22.28572 159.4286	6	MEGNO	13:22	22.34018 159.66253	1									
17	DOLPH	15:35	22.32315 159.3618	7	STELO	14:32	22.21685 159.62193	1									

4 The aerial team recorded humpback whales, which are not listed in this table.
5 Humpbacks which are reported in this table were investigated for associated odontocetes.

Table 8. Summary of marine mammal sightings for 2/20/2011

Searcher						RHIB							
Sighting #	Species	Time	Location	BSS	Notes	Sighting #	Species	Time	Location	BSS	Group size	Tags	Notes
1	TURTR	07:51	22.28075 159.51675	2		1	TURTR	07:51	22.28531 159.51743	3	3/4/4		2 bowriders
2	TURTR	08:31	22.27975 159.59418	3		2	TURTR	08:31	22.27789 159.59595	3	1/1/1		1 bowrider

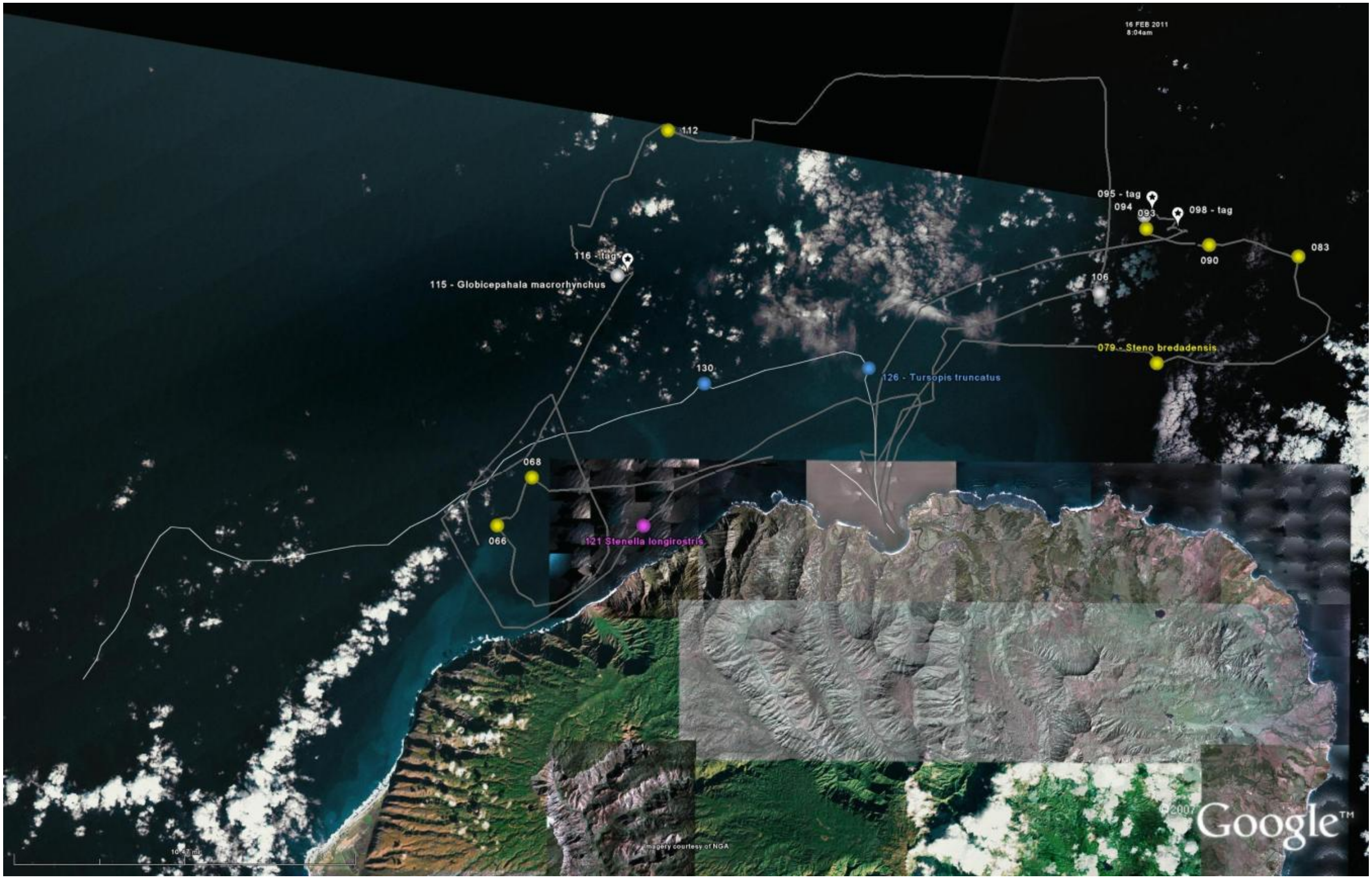

Figure 15. Sightings of Odontocetes from RHIB during 02/17 - 02/20/2011

Figure 16. Locations of tag deployments on Globicephala macrorhynchus *(see waypoints 095 and 096, deployed on 18 February 2011 and waypoint 116, deployed on 19 February 2011)*

Figure 17. Pilot whale from aircraft

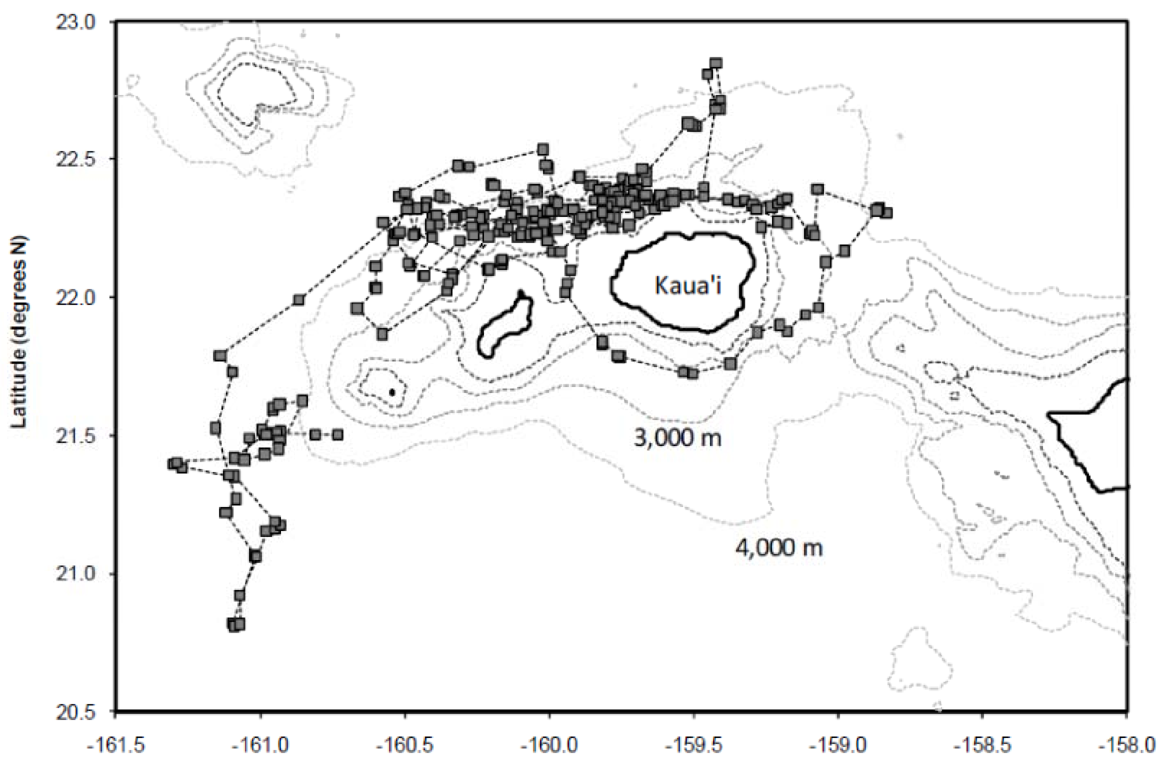

Figure 18. Movement of three satellite-tagged pilot whales tagged off Kauaʻi in February 2011

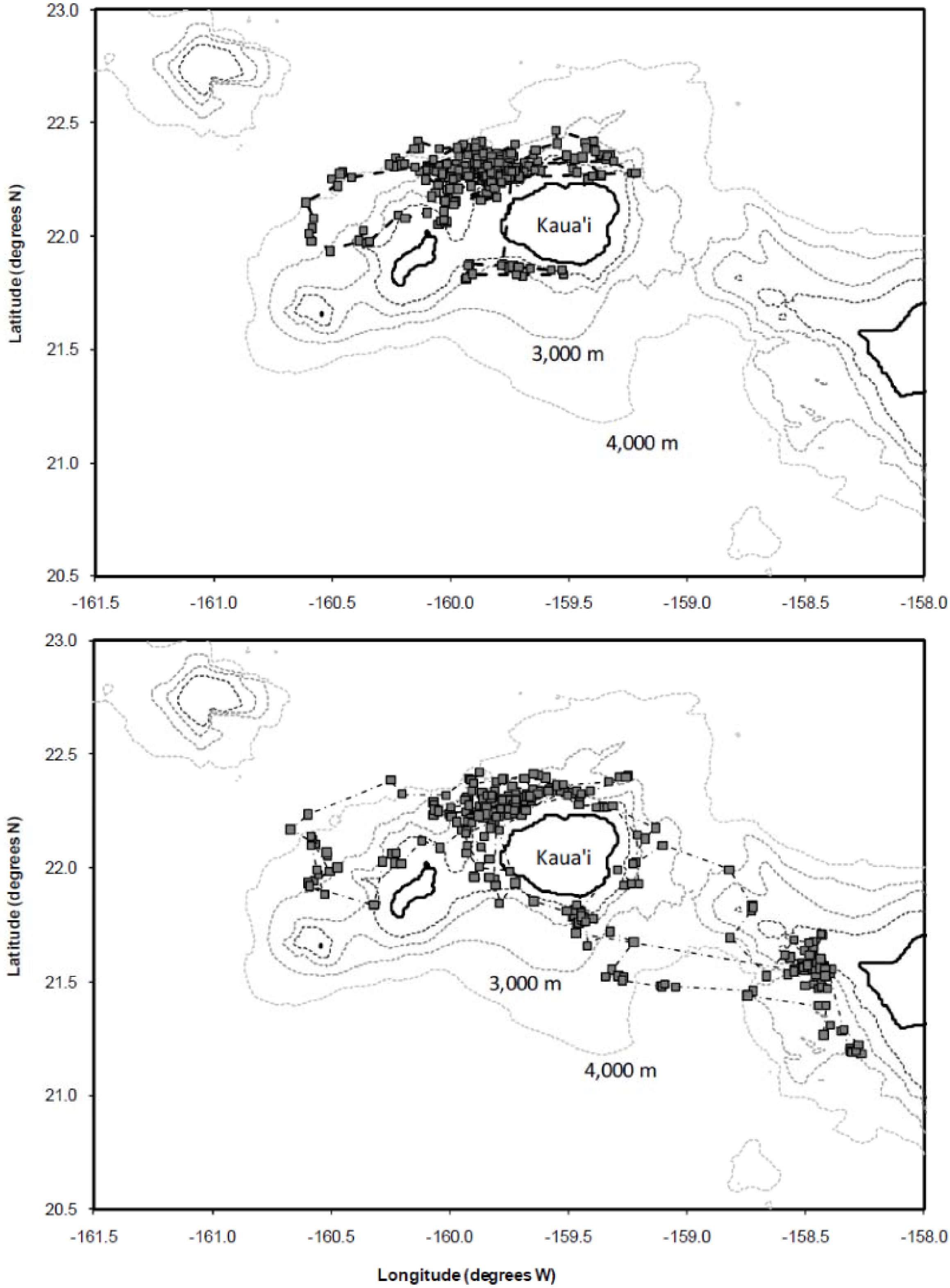

Figure 19 (continued). Movement of three satellite-tagged pilot whales tagged off Kaua'i in February 2011

4.3 Conclusion

4.3.1 Summary of independent report from Cascadia Research Collective

The three pilot whales which were satellite tagged appeared, based on CRC analysis, to be from different social units. One sub-group had had no previous sightings, based on photo-identification. Another sub-group had been sighted previously off the island of Oahu. Results from this work represent a significant increase in our understanding of short-finned pilot whales residency patterns and spatial use of areas adjacent to and on the Navy Range (Baird 2011). Baird 2011 is found in appendix J of this report.

4.3.2 Monitoring conclusions

If number of satellite transmissions are used as a proxy for the amount of time spent in a particular location, then all three groups of short-finned pilot whales appear to be substantially utilizing habitat within and adjacent to PMRF, within the monitoring period. This suggests that the area north of the channel between Ni'ihau and Kaua'i may have importance to this species. Additional monitoring and research is needed to determine what behaviors the animals are engaging in to more fully understand how and when this habitat area is being utilized. Analyzing the animal movements in conjunction with SONAR transmission during SCC may provide data on whether animals displaced to another location during the exercise.

SECTION 5 ACKNOWLEDGEMENTS

This vessel based survey and tagging effort was coordinated by NAVFAC-Pacific in cooperation with Cascadia Research Collective, and funded by Commander, U.S. Pacific Fleet. Thanks to Dr. Robin Baird, Daniel Webster, and Jessica Aschettino of Cascadia Research Collective. Thanks to Michele Bane of Kaua'i Marine Mammal Response Program, NOAA. Thanks to the crew of the r/v *Searcher*.

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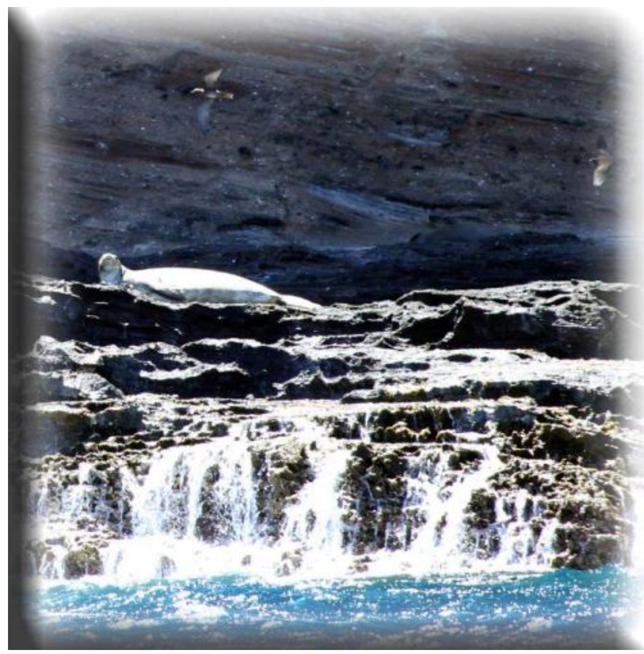
APPENDIX D. Ka'ula Island Ship-based Marine Mammal Survey June 30, 2011, Hawaii Range Complex. Final Report.

August 12, 2011
Final Report
Ka'ula Island Ship-based Marine Mammal Survey June 30, 2011
Hawaii Range Complex

Prepared for:
Commander, U.S. Pacific Fleet



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List of Acronyms and Abbreviations

ft	feet
HRC	Hawaii Range Complex
kts	knots (nautical miles per hour)
m	meters
MFAS	mid-frequency active sonar
MMO	Marine Mammal Observer
nm	nautical miles
NMFS	National Marine Fisheries Service
PMAP	Protective Measures Assessment Protocol
PMRF	Pacific Missile Range Facility
RIMPAC	Rim of the Pacific, (Major Training Exercise)

1. INTRODUCTION

1.1 MARINE MAMMAL AND SEA TURTLE MONITORING

In order to train with mid-frequency active sonar (MFAS), the Navy has obtained a Letter of Authorization (permit) from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and a Biological Opinion under the Endangered Species Act. The Hawaii Range Complex (HRC) Monitoring Plan, finalized in December 2008 for implementation in January 2009, and amended in 2010, was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting will provide science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy MFAS. The objectives of the monitoring plan are to answer the following questions:

1. Are marine mammals and sea turtles exposed to MFAS at regulatory thresholds of harm or harassment? If so, at what levels and how frequently are they exposed?
2. If marine mammals and sea turtles are exposed to MFAS in the HRC, do they redistribute geographically in the HRC as a result of repeated exposure? If so, how long does the redistribution last?
3. If marine mammals and sea turtles are exposed to MFAS, what are their behavioral responses? Are they different at various levels?
4. What are the behavioral responses of marine mammals and sea turtles that are exposed to various levels and distances from explosives?
5. Are the Navy's suite of mitigation measures for MFAS and explosives (e.g., Protective Measures Assessment Protocol [PMAP], measures agreed to by the Navy through permitting and consultation) effective at avoiding harm or harassment of marine mammals and sea turtles?

The Ka'ula Island monitoring effort is intended to provide data towards answering questions 1, 2, and 5 above.

1.2 KA'ULA ISLAND BACKGROUND

1.2.1 Property Description

Ka'ula is a small, uninhabited islet near the islands of Niihau and Kauai in the Hawaiian Archipelago (Fig. 1; latitude: 21°39'29" North, longitude: 160°32'39" West; Palmer 1936). It is located 20 nautical miles (37 kilometers [km]) west-southwest of Niihau and approximately 60 nautical miles (111 km) southwest of the Pacific Missile Range Facility (PMRF) Main Base, Kauai. Ka'ula has an area of approximately 136 acres (55 hectares), with a summit elevation of 540 feet (ft) (164.6 meters [m]) (Palmer 1936). The island is crescent-shaped, with a curving crest line approximately 5,500 ft (1,676 m) in length (Fig. 2). The terrain drops steeply from the crest at a mean slope of 36° (Palmer 1936), and steep V-shaped ravines have been cut by ephemeral streams on the windward slopes, such that the island has little level terrain (Elmer and Swedberg 1971). The northern horn of the island extends 2,500 ft (762 m) from the summit and ends at an approximate elevation of 280 ft (85 m), while the southern horn extends 3,000 ft (914 m) from the summit and ends at an approximate elevation of 100 ft (30 m) (Palmer 1936). The southeastern tip (1000 ft) of the island is currently used by the U.S. Navy as a range for inert ordnance and aircraft gunnery (Fig. 2). During a 1971 survey, a freshwater source was recorded approximately 1,000 ft (305 m) from the impact area with a flow rate of approximately 1 pint (0.47 liters) per hour (Elmer and Swedberg 1971).

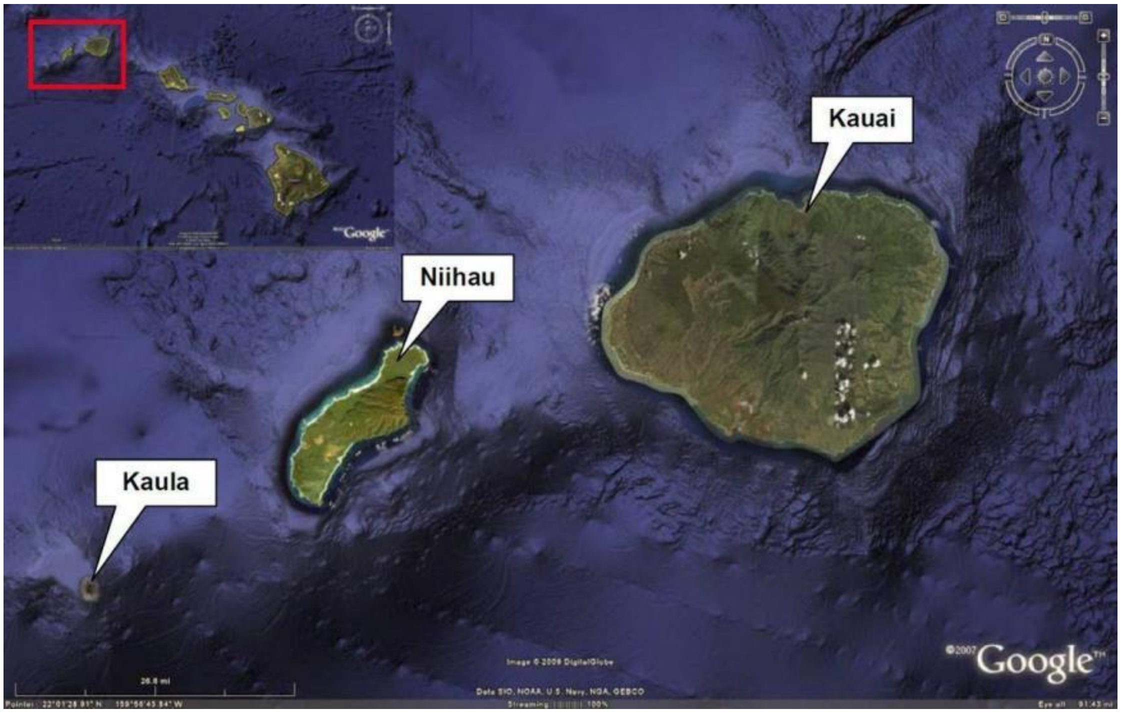

Figure 1. Location of Ka'ula Island relative to the main Hawaiian Islands (inset) and Kauai and Niihau (imagery from Google Earth).

Figure 2. Aerial imagery of Ka'ula Island (Walker and Associates).

1.2.2 Prior Use

The U.S. Lighthouse Service established an automatic gas light near the summit of Ka'ula Island on August 18, 1932. Lighthouse Service personnel were able to land on the west side of the island during steady trade wind weather, and an ascent trail was built from a wave-cut bench near sea level to the lighthouse site near the summit (Palmer 1936). The gas light provided 480 candlepower and was visible for a distance of up to 27 miles in clear conditions. Two gas tanks on the west side of the island supplied fuel to the main and backup light via 1,500 ft-long pipes. The lighthouse on Ka'ula was operated until 1947.

Following World War II, USCG used Ka'ula Island as a radar navigation target. In 1952, after receiving permission to use the island for munitions training, the Navy designated the southeastern tip (1000 ft) of the island as a practice range for air-to-surface and surface-to-surface weapons delivery (Elmer and Swedberg 1971, DON 1976a). Both live and inert ordnance were used during training missions through 1980. From 1981 through the present, the Navy restricted its munitions training at Ka'ula to inert ordnance delivery and aircraft gunnery (Walker 1979, 1983, 1984, 1993).

1.2.3 Marine Mammal Survey History and Species Observations

Two National Oceanic and Atmospheric Administration (NOAA) marine mammal surveys, not associated with the on-island plant and seabird surveys at Ka'ula Island, have examined the waters surrounding the island (Mobley et al. 2000, Baird et al. 2003). Both surveys recorded spinner dolphins (*Stenella longirostris*) and bottlenose dolphins (*Tursiops truncatus*) near Ka'ula (Mobley et al. 2000; Baird et al., 2003). In March 2000, Mobley et al. (2001) sighted killer whales (*Orcinus orca*) in nearby waters offshore the west coast of Niihau (~27km NW of Ka'ula).

Since 1998, access to the island for land-based surveys has not been granted due to increasing concerns by the Navy regarding the potential for injury to personnel visiting Ka'ula by unexploded ordnance, bird aircraft strikes, and steep, unstable terrain. In January 2009, the Navy contracted a private company to obtain aerial imagery of Ka'ula Island via small airplane in order to conduct seabird surveys using high-resolution digital images. The resolution of the imagery obtained during those flights, however, was not high enough to accurately assess seabird species abundance or presence on the island.

On 21-22 July 2009 avian surveys were conducted by Navy biologists via vessel platform to continue collection of seabird data on Ka'ula Island in the absence of direct access to land. Marine mammals surveys were conducted concurrently (Pepi et al. 2009), marking the beginning of a series of surveys incorporating marine mammal effort on the avian survey vessel. Subsequent surveys have occurred in June 2010, Feb 2011, and the topic of the current report, June 2011. Below follow summaries of the three past surveys in this series:

<u>21-22 July 2009</u>

Five biologists, including four seabird observers and one marine mammal observer, carried out this survey. This group included a seabird observer from the US Fish and Wildlife Service, as well as one from the Hawaii State Department of Land and Natural Resources. Observations of seabirds and marine mammals were conducted from the platform above the bridge, approximately 24 ft (7 m) above the water. Four species of marine mammals were observed near Ka'ula Island, including three species of odontocetes and one species of pinniped. Bottlenose dolphins (*Tursiops truncatus*) and spinner dolphins (*Stenella longirostris*) were all sighted off of the northwest coast of the island within 820 ft (250 m) of the coastline. The spotted dolphins (*Stenella attenuata*) were sighted during transit to the survey area off of the southeast coast of Ka'ula within 4.9 miles (8 km) of the coastline. Hawaiian monk seals (*Monachus schauinslandi*) were observed hauled out on two separate ledges on the leeward (western) side of the island.

<u>26-28 June 2010</u>

Seven biologists, including three participating as marine mammal observers, carried out this survey. This group included a seabird observer from the US Fish and Wildlife Service, as well as one from the Hawaii State Department of Land and Natural Resources (Uyeyama & Hanser, 2010). The survey was conducted from the same vessel as the July 2009 effort. Marine mammal surveys were also conducted in waters between Kauai and Niihau, and the vessel was outfitted with two pairs of 25x150 Fujinon "Big Eye" binoculars mounted on the platform above the bridge. Species observed near Ka'ula were spinner dolphins (*Stenella longirostris*) approximately 1 km east of Ka'ula, and false killer whales (*Pseudorca crassidens)* approximately 21km ENE of Ka'ula (about halfway between Ka'ula and Niihau). The two adult *Pseudorca* dorsal fins did not match any animals in the Cascadia Research Collective catalog of photographs for the Insular Hawaiian population. Additionally, two sightings of bottlenose dolphins (*Tursiops truncatus)* were made offshore Niihau, and rough-toothed dolphins (*Steno bredanensis)* were sighted off the SW shore of Kauai. No Hawaiian monk seals were sighted.

<u>15-20 February 2011</u>

Due to limited space for personnel aboard the vessel, no dedicated marine mammal effort was conducted at the portion of the cruise that investigated waters offshore Ka'ula, although on-effort sightings during the transit from Niihau included two large whales (one unidentified ~18km NE of Ka'ula, and one humpback whale [*Megaptera novaeangliae]* ~10km NE of Ka'ula*),* and an in-water Hawaiian monk seal (*Monachus schauinslandi)* upon arrival at Ka'ula. Additionally, an off-effort sighting was made offshore of Ka'ula of a pod of spinner dolphins (*Stenella longirostris*) during the circumnavigation of the island for the avian survey. Also bottlenose dolphins (*Tursiops truncatus)* were sighted offshore the northern tip of Niihau ~2km NE of Lehua islet.

After the initial portion of the cruise dedicated to the avian survey at Ka'ula, there was a personnel change of the science crew aboard the vessel to a dedicated marine mammal group, enabling the subsequent phase of the cruise which was a marine mammal tagging and survey effort. This phase was concentrated on performing a tagging effort offshore of Kauai that involved deploying a dedicated RHIB operated by three biologists from Cascadia Research Collective (Richie & Fujimoto, 2011). In addition, there were three marine mammal biologists on the main vessel including one from NOAA's Kauai Marine Mammal Response Program. Due to prevailing weather conditions, the effort was performed in waters off the north shore of Kauai.

<u>Additional sightings</u>

Additionally the NOAA PIFSC on August 2, 2006, June 3, 2010, and July 6, 2010, and the Hawaii state DLNR Kauai Division of Aquatic Resources (on unidentified dates) have observed Hawaiian monk seals (*Monachus schauinslandi*) ranging in number between 3 and 15 animals (personal communication, 2011).

2. METHODS

2.1 SHIP-BASED SEA BIRD AND MARINE MAMMAL SURVEY: June 30, 2011.

Ship-based surveys were again conducted for seabirds and marine mammals offshore of Ka'ula Island and in the waters between Niihau and Kauai on 30 June 2011.

The waters of the survey area included the PMRF areas W-186 and W-187 (Fig. 3). Eight biologists, including six from the U.S. Navy, one from the NOAA Protected Species Division, and one from the University of Hawaii, carried out the surveys (Table 1). Surveys were conducted from the Motor Vessel Searcher, a 96 ft (29.3 m) ship capable of sleeping a scientific crew of eight, and is owned and operated by the Medical Foundation for the Study of the Environment. The M/V Searcher has an observation deck above the bridge, placing observers approximately 24 ft (7 m) above the surface of the water (Fig. 4). Distance to the horizon from this height was ~8 nm. A canopy structure covered the flying bridge to minimize exposure of observers and equipment to sun and rain.

2.2 SURVEY TIMELINE

The scientific crew of eight biologists boarded the M/V Searcher at Nawiliwili Harbor, Kauai, on the evening of 29 June. The vessel made the transit to Ka'ula overnight, and the marine mammal survey effort began on the morning of June 30 approximately 4.5km NE of Ka'ula as the vessel approached the island at approximately 12 knots over the course of an hour. Upon reaching Ka'ula, a bird survey was conducted during three circumnavigations of the island. Subsequently, the vessel dedicated time to obtaining dorsal fin photographs of bottlenose and spinner dolphins observed off the SE shore of the island during the bird survey. The vessel then headed ~5km to the NE of the island to deploy a passive acoustic device offshore, then returned to the island to examine hauled-out monk seals originally observed during the bird survey. Afterwards, the vessel transited directly to Kauai, during which a marine mammal survey was conducted. All of the scientific crew disembarked immediately upon arrival at Port Allen at the end of the day of 29 June.

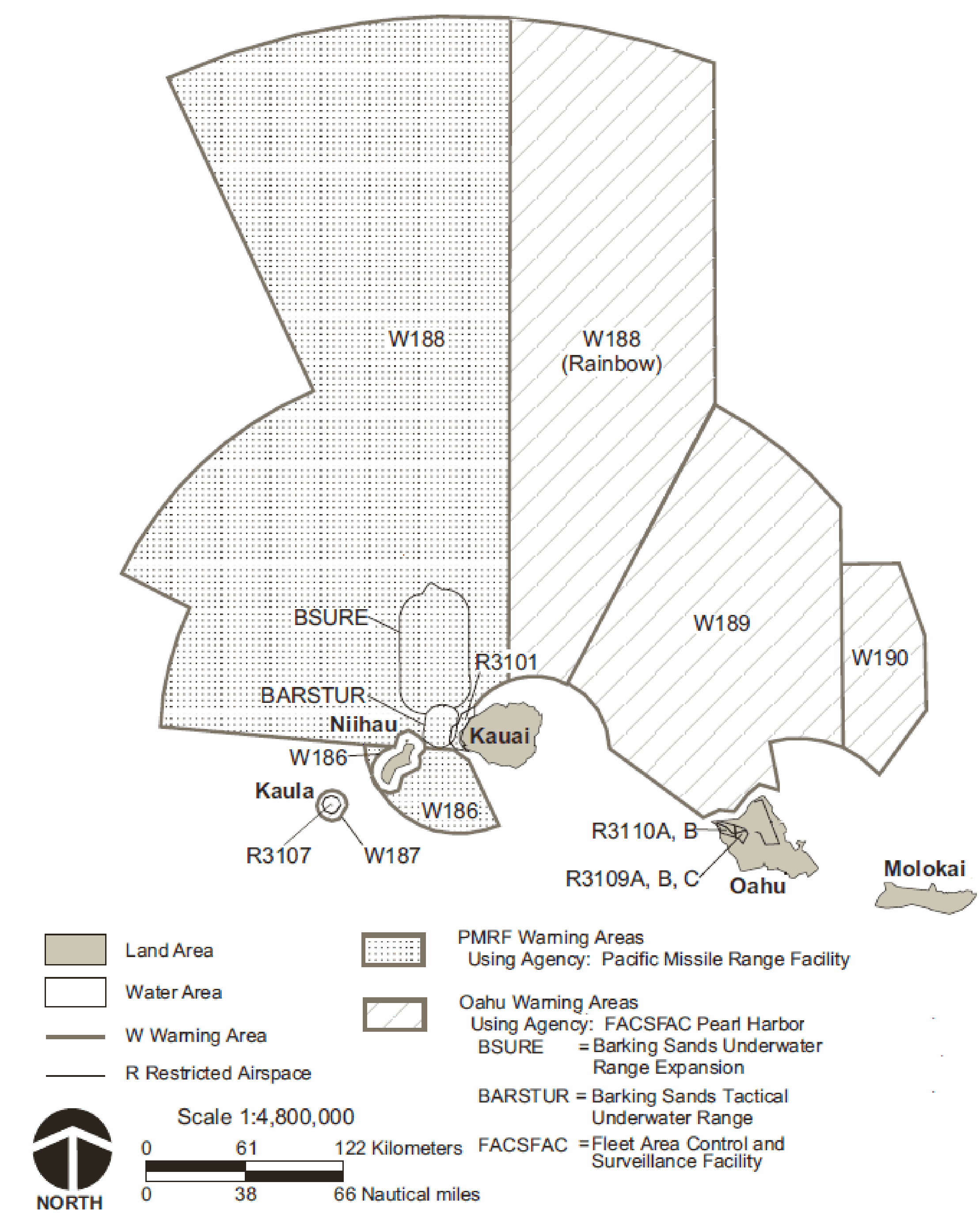

Figure 3. Depiction of PMRF Warning Areas W-186 and W-187 in relation to the Hawaiian Islands

Figure 4. M/V Searcher. A view from the stern shows several decks, including the covered flying bridge at top.

2.3 SHIP-BASED MARINE MAMMAL SURVEY METHODOLOGY

Data collection protocols and forms generally followed those used during previous vessel-based marine mammal and sea turtle monitoring programs conducted in conjunction with other naval exercises in the HRC (Smultea et al. 2007, 2008a, 2008b). The marine mammal survey portion of the cruise was conducted by four Navy biologists. The primary goals were to locate and identify marine mammals and sea turtles. Two biologists were experienced with line-transect survey methodology and had experience in field identification of subtropical Pacific marine mammal and sea turtle species, were knowledgeable of marine mammal biology and behavior, and had previous experience conducting marine mammal observations from vessels. Observations were made from the flying bridge of the M/V Searcher. Each observer rotated through three stations at 30-minute intervals: port observer, data recorder, and starboard observer. The data recorder also was able to make opportunistic observations. All three observers were equipped with 7x hand-held reticled binoculars. All observers were also equipped with digital cameras, two with a 400mm zoom lens, and one with a wide-angle zoom lens. The survey during the initial leg to Ka‘ula, as well as the return transit to Kauai was conducted in “passing mode,” i.e., the vessel was not diverted from the track line in the case of sightings. Once a sighting occurred, all three observers on duty were assigned the task of projecting independent estimates of group composition using a minimum, maximum, and best estimate approach. The average of the “best” estimates from the three observer team was then recorded for group size.

Except for the portion of the cruise devoted to the bird count during circumnavigations of Ka‘ula Island, the marine mammal survey effort occurred during all daylight hours during “acceptable” survey conditions (i.e., Bf <=5) with no rain or other environmental conditions impeding the ability to sight marine mammals near the vessel.

3. RESULTS

A total of six marine mammal groups were sighted during the cruise (Table 1) across a total of 11 hours 29 minutes of survey effort. All of the sightings were confirmed to species and consisted of three groups of bottlenose dolphins (*Tursiops truncatus*), one group of rough-toothed dolphins (*Steno bredanensis*), one group of spinner dolphins (*Stenella longirostris*), and a set of hauled-out Hawaiian monk seals on a short stretch of shoreline. At least one calf was among the Hawaiian monk seals, and a juvenile was sighted within one group of bottlenose dolphins, as well as within one group of spinner dolphins. No sea turtles were sighted.

Table 1. Summary of marine mammal sightings

Species	Group size (Min/Max/Best)	Date	Time (HST)
Stenella longirostris	16/37/26	30 June	07:40*
Monachus schauinslandi	5/5/5**	30 June	07:52
Tursiops truncatus	10/17/13	30 June	09:35
Tursiops truncatus	2/3/2	30 June	11:25
Tursiops truncatus	5/7/6	30 June	13:52
Steno bredanensis	4/8/6	30 June	17:21

All sightings and their locations with reference to survey tracks are depicted in Figs. 5 & 6.

* resighted at approximately same location on each of two successive circumnavigations of island

** original group size estimate was 2/3/2; when the location was more closely approached at 10:54-11:20, Five animals were counted, including two animals that hauled out of the water during this later approach

The marine mammal survey effort began on the morning of June 30 approximate 4.5km NE of Ka'ula (Fig. 5). Upon reaching Ka'ula Island, as with the 2009 ship-based survey, a seabird survey of the island was conducted as the vessel circumnavigated the island at a distance of approximately 750 ft (228 m) from the coastline; actual distance varied from approximately 150m to 600m depending on the bottom depth. The avian survey consisted of three clockwise circumnavigations of the island to provide multiple counting opportunities across different observers. Marine mammal sighting effort during the avian survey consisted of the NOAA monk seal biologist and one Navy biologist scanning the shoreline opportunistically during the vessel's circumnavigations; the water surface was not scanned continuously as for the dedicated marine mammal survey portion of the cruise. During the avian survey, two monk seals were sighted hauled-out on the NW corner of the island; it was decided that the vessel would return to this location after completing other tasks for a closer and dedicated search for monk seals so that the sun will have risen to maximally within the available survey window to light the shoreline area; standardized NOAA monk seal surveys are typically conducted closer to mid-day, when seals are most likely to haul out. Also a group of approximately six spinner dolphins were sighted at the SE tip of the island during each circumnavigation, and photographing of dorsal fins was attempted from the bow of the vessel by one biologist.

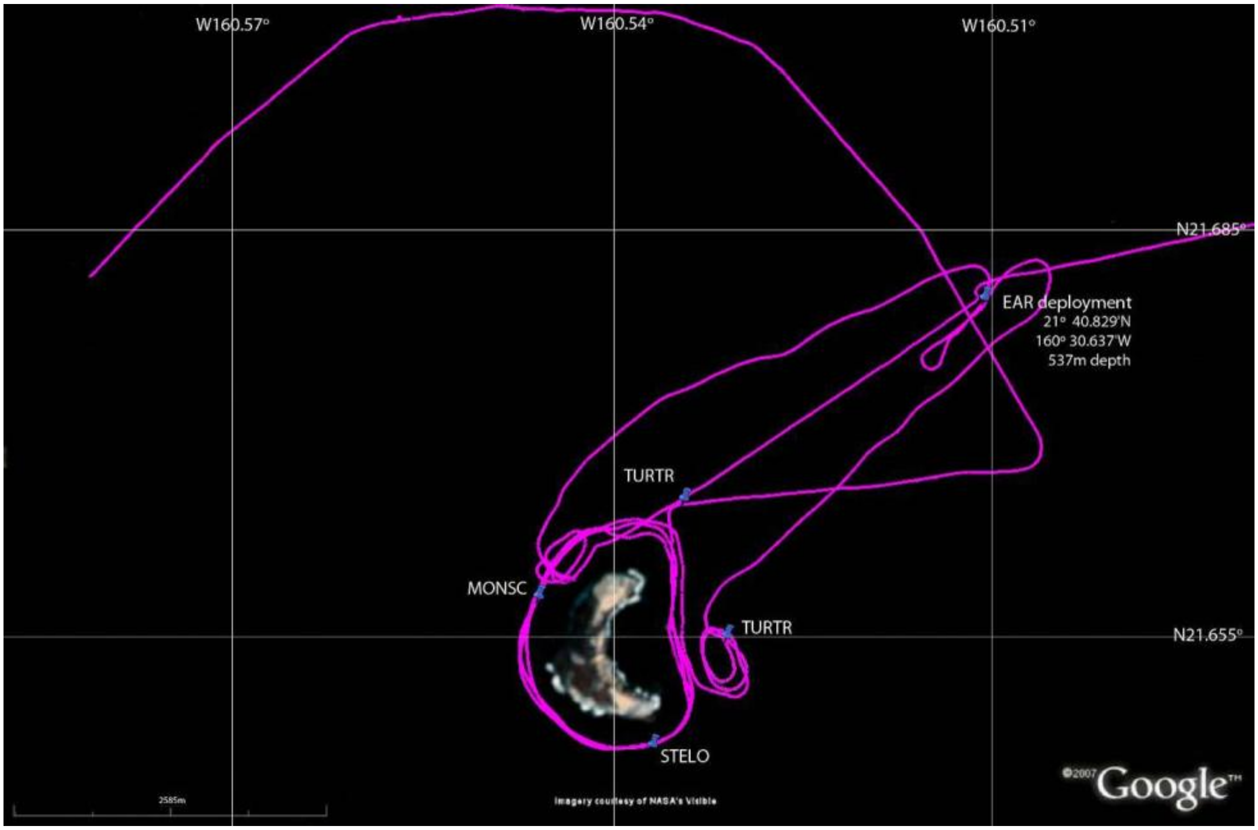

Figure 5. Sightings and EAR deployment near Ka'ula STELO=Stenella longirostris, TURTR=Tursiops truncatus, MONSC=Monachus schauinslandi. On-effort marine mammal survey track begins at far left, followed by three clockwise circumnavigations of Ka'ula during the avian survey, following a group of bow-riding Tursiops to the east of Ka'ula, deploying the EAR, re-examining hauled-out monk seals on the NW shore of Ka'ula, checking the EAR deployment, and departing for the return transit to Kauai with continued marine mammal survey effort. Imagery adapted from Google Earth.

After the avian survey, efforts were dedicated toward:

1. Obtaining spinner dolphin dorsal fin photographs for individual identification purposes
2. Deploying a passive acoustic monitoring device (an EAR) offshore to the east of the island
3. Examining the NW shore of the island where monk seals had been sighted
4. Conducting marine mammal survey in passing mode during the return transit to Kauai (Fig. 6)

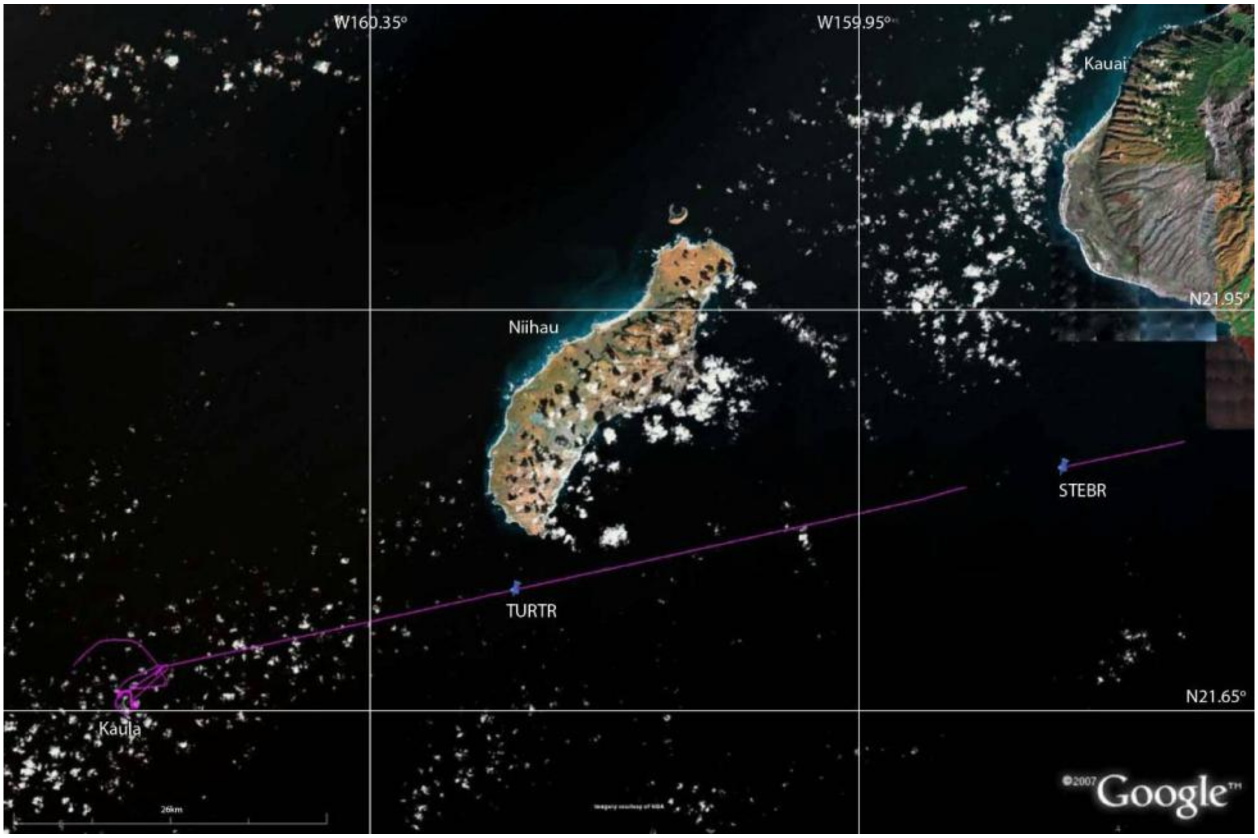

Figure 6. Overall on-effort track of June 30, 2011 with sightings. Effort begins at far left NW of Ka'ula. Sightings on the return transit from Ka'ula to Kauai are shown. TURTR=Tursiops truncatus, STEBR=Steno bredanensis. Detail of area near Ka'ula are shown in Fig. 5. Imagery adapted from Google Earth.

Dorsal fin photography: Two biologists were positioned at the bow of the vessel to take dorsal fin photographs (Appendix B) of bow-riding spinner dolphins (Fig. 7) off the SE shore of the island. Photography of these dolphins continued until reaching the waters directly off the central eastern shore, when a group of bottlenose dolphins were encountered, and as these began to bow-ride, the spinner dolphins were apparently displaced and departed from sight.

Photographic effort shifted to documenting the dorsal fins of the bottlenose dolphins (Appendix A) for approximately 20 minutes, until the animals departed. A large fraction of the animals had multiple cookie-cutter shark scars (Fig. 8), as well as a few individuals with fresh cookie-cutter shark wounds. The bottlenose dolphins were breaching and spiral-swimming, and many of the individuals appeared to be attempting to dislodge remoras with aerial behaviors (Fig. 9). Several individuals were identified as male by observing the genital region during leaping behaviors.

For comparison with existing libraries of marine mammals in Hawaiian waters, all photographs of spinner dolphin dorsals were provided to PIPIN (Pacific Islands Photo-Identification Network), and those of bottlenose dolphins to Cascadia Research Collective and The Dolphin Institute.

Figure 7. Spinner dolphins (Stenella longirostris) at Ka'ula

Figure 8. Bottlenose dolphin (Tursiops truncatus) at Ka'ula. This individual and several others in the group had cookie-cutter shark scars.

Figure 9. Bottlenose dolphin (Tursiops truncatus) at Ka'ula exhibiting aerial behavior with multiple remoras.

Acoustic device deployment: The biologist from the University of Hawaii deployed the passive acoustic device. The device was an Ecological Acoustic Recorder (EAR) (Lammers et al., 2008) (Fig. 10), and was configured for a long-term deployment of six months with a duty cycle of recording for 30 seconds every five minutes with a sampling rate of 80kHz. The device is a relatively compact package that is designed to be deployed by hand without use of heavy machinery such as a winch (Fig. 11).

The intention had been to deploy at 800m depth, as found near approximately 21º 40'N 160º 31'W. This location will complement three other EARs that are planned to be deployed in July 2011 in nearby waters offshore the northern, southwestern, and eastern shores of Niihau at a depth of approximately 800m.

When it was determined that the vessel's depth sounder displayed only to a maximum depth of 500m, and because the bottom drop-off was steep and not "smooth" in this area, it was decided to make a conservative deployment at just beyond 500m. Therefore, the vessel moved to the 500m contour, then moved offshore from this location before deploying. The actual deployment location was 21º 40.829'N 160º 30.637'W at a depth of 537m, approximately 5 km NE of the circumnavigation trackline for the avian survey.

Figure 10. Components of the EAR device. Pictured are ballast (cement and sand bag), acoustic release, syntactic foam float with signal flag, and EAR acoustic recording device.

Figure 11. Deployment of EAR. The EAR is designed to be manually deployable without heavy equipment. Deployment location was 21º 40.829'N 160º 30.637'W at a depth of 537m. See Fig. 5 for location relative to Ka'ula.

Figure 12. Communicating with EAR acoustic release to confirm deployment orientation and depth. Display at upper left reads a depth of "537 m"; vertical deployment orientation was also confirmed.

Hawaiian monk seal effort: Due to the requirement to wait for the EAR to sink fully to its deployment depth before checking its deployment status by communicating with the acoustic release device, the vessel departed and returned to the NW shore of Ka'ula, to where monk seals had been sighted during the avian survey. The vessel moved closer to approximately 200m from the shore, and transited slowly across this area for approximately 25 minutes. The two monk seals originally sighted during the avian survey were re-sighted, as well as three additional animals that hauled out during this closer dedicated monk seal survey period. All five hauled-out monk seals were photographed with cameras equipped with 400mm lenses (Fig. 13, 14). At minimum one individual (one of the two that hauled out during this closer approach) appeared to be a juvenile (Fig. 14). All five animals were sighted on the ledge shoreline to the south of the large sea cave visible from the NW side of Ka'ula (Figs. 15, 16). Only one animal's posterior flippers were well visualized by photography as it hauled out, and no artificial identification tags were visible on this animal (Fig. 17).

There were a total of five seals observed. All were of unknown sex because the ventral area was not clearly visualized in photographs or observations to make a determination. This size class composition was: 2 adults, 1 immature, 1 juvenile, and 1 undetermined size.

After the effort was complete, the vessel returned to the EAR deployment location where, by communication with the acoustic release device, successful deployment was verified and vertical orientation and depth were determined (Fig. 12). All photographs of monk seals were provided to the NOAA Protected Species Division.

Figure 13. Three Hawaiian monk seals (Monachus schauinslandi) hauled out at NW shore of Ka'ula. From left to right: adult, immature (note green algae on hind flippers), and undetermined size.

Figure 14. Two Hawaiian monk seals (Monachus schauinslandi) hauled out at NW shore of Ka'ula. These animals were located to the right (as seen from the boat) of the three animals shown in Figure 13. One appears to be a juvenile.

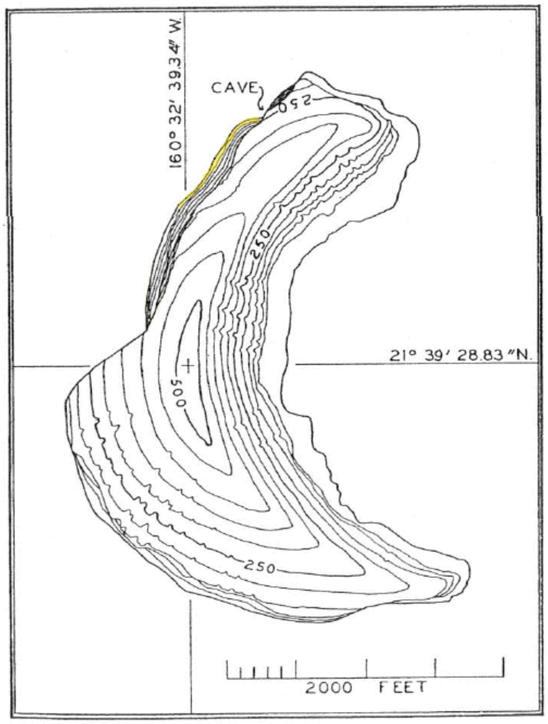

Figure 15. Map of Ka'ula showing location of sea cave and the shoreline (yellow) visible to its south upon which monk seals were sighted. (Figure adapted from Palmer, 1936, p. 7.)

Figure 16. Sea cave viewed from northernmost tip of Ka'ula. Monk seals were sighted on the ledge beyond the image to the right of the cave.

Figure 17. Close view of monk seal showing probable lack of an artificial flipper tag. This animal is also pictured at the far right of Fig. 13.

4. CONCLUSIONS

4.1 NIIHAU-KAUAI-KAʻULA PROJECT AREA

Few data are available from intensive marine mammal surveys specific to the waters surrounding the Niihau-Kauai project area, and only two that extend to Kaʻula Island (Mobley et al. 2000, Baird et al. 2003) other than the recent series of combined seabird-marine mammal surveys (Pepi et al., 2009; Uyeyama et al., 2010; Richie & Fujimoto, 2011). Therefore, comparison to past studies with the results of this survey are difficult to interpret.

However, as this survey is the fourth of a series of surveys envisioned to be conducted in conjunction with Kaʻula Island sea bird surveys, possible goals for long term monitoring have become apparent. The deployment of a passive acoustic monitoring device to the waters surrounding the island is intended to begin a long-term acoustic survey of these waters, and will complement three devices to be placed around Niihau. Every effort has observed spinner dolphins at Kaʻula, suggesting the possibility of a resident population. Other cetacean species have been regularly observed, and the characterization of these populations and their relation to other populations within Hawaiian waters may be possible with the continued use of photo-identification, as well as biopsy of satellite tagging—also individual animals satellite-tagged nearby in waters offshore Kauai may potentially reveal transits of these animals to Kaʻula. In this survey, it was planned that should an interesting species be sighted, for example a beaked whale or blackfish species, that the vessel would be directed to break from its track to follow these animals for photo-ID and behavioral recording. However, these species were not sighted, and the two longer sightings of dolphin species appeared to be cases where the animals approached the vessel to bowride, which facilitated photography of dorsal fins. The characterization of monk seals at Ka'ula can also be conducted due to the planned regularity of future surveys; it is possible that closer approaches by small boats may allow individual identification through either natural marks or artificial tags.

4.2 SURVEY PROTOCOL

The cooperative combination of marine mammal and sea turtle survey effort with long-term vessel-based sea bird surveys of Ka'ula Island have continued to prove to be a cost-effective and productive research procotol. The collection of data in these waters utilizing these proven methods are anticipated to continue to provide baseline information regarding marine mammal and sea turtle populations in the Hawaii Range Complex.

Having an experienced monk seal biologist from NOAA was useful to have during the seabird portion of the survey, as the seals are quite difficult to sight from the distance of the bird survey track, especially when there is a swell or waves due to wind. The NW corner of Ka'ula to the south of the cave where the five monk seals were observed this cruise (Fig. 15) may be a frequently used haul out location. No seals were observed on the ledge of the SW shoreline near the southern tip of the island where seals had been observed on the 2009 cruise. It is worth noting that these Western shorelines are in shadow through most of the early morning, and that the seals are known to be also less likely to haul out in the earliest part of the morning. Therefore it was beneficial that the science team performed monk seal observations after other tasks (such as PAM deployment and cetacean dorsal fin photography) had been completed, because there was more sunlight available, and additional seals did haul out as compared to the earlier observations during the avian survey leg. The 400mm lenses were sufficient to capture photography from the safe distance from shore required by the M/V Searcher. Photography or shorelines where monk seals were not apparent in binoculars was also performed for a post-survey examination for more seals; no additional seals were positively confirmed through such photography.

Regarding cetacean dorsal fin photography, the relatively high position of the M/V Searcher's bow, as well as the dolphins' tendency to be bow-riding directly below the bow made it difficult to obtain photography with the particularly high quality and perpendicular angle necessary for individual identification of spinner dolphins. However photography of the bottlenose dolphins was judged to be sufficient for individual identification purposes.

The M/V Searcher's echosounder was only capable of displaying bottom depths to 500m. Due to the steep and unpredictable dropoff in the area, PAM deployment was therefore performed by moving slightly offshore of the 500m isobaths, then deploying. This method was judged to be a good balance between the risk of deploying past the device rating of 1000m, yet closer to the ideal depth of 800m. A successful deployment was thereby accomplished to a depth of 537 m which is sufficient for detecting high priority deep-diving odontocetes such as beaked whales.

4.3 ACKNOWLEDGEMENTS

We thank the crew of the M/V Searcher for their hospitality and safe execution of the survey, as well as Brenda Becker of the NOAA PIFSC Protected Species Division, for expert participation in, and advice during, the survey as well as insightful comments during the writing of this report.

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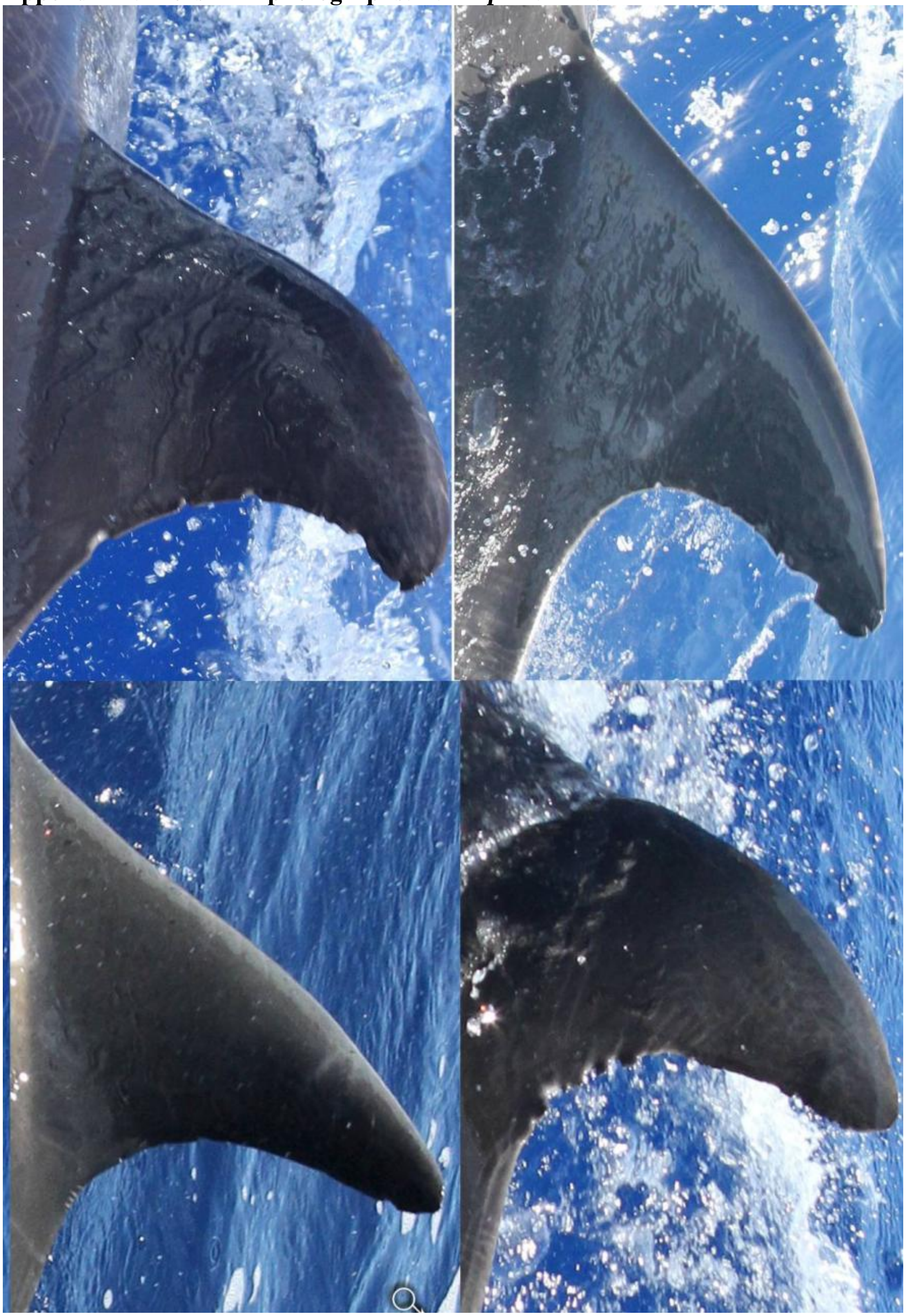
Appendix A. Dorsal fin photographs: *Tursiops truncatus*



Appendix A. Dorsal fin photographs: *Tursiops truncatus* (continued)

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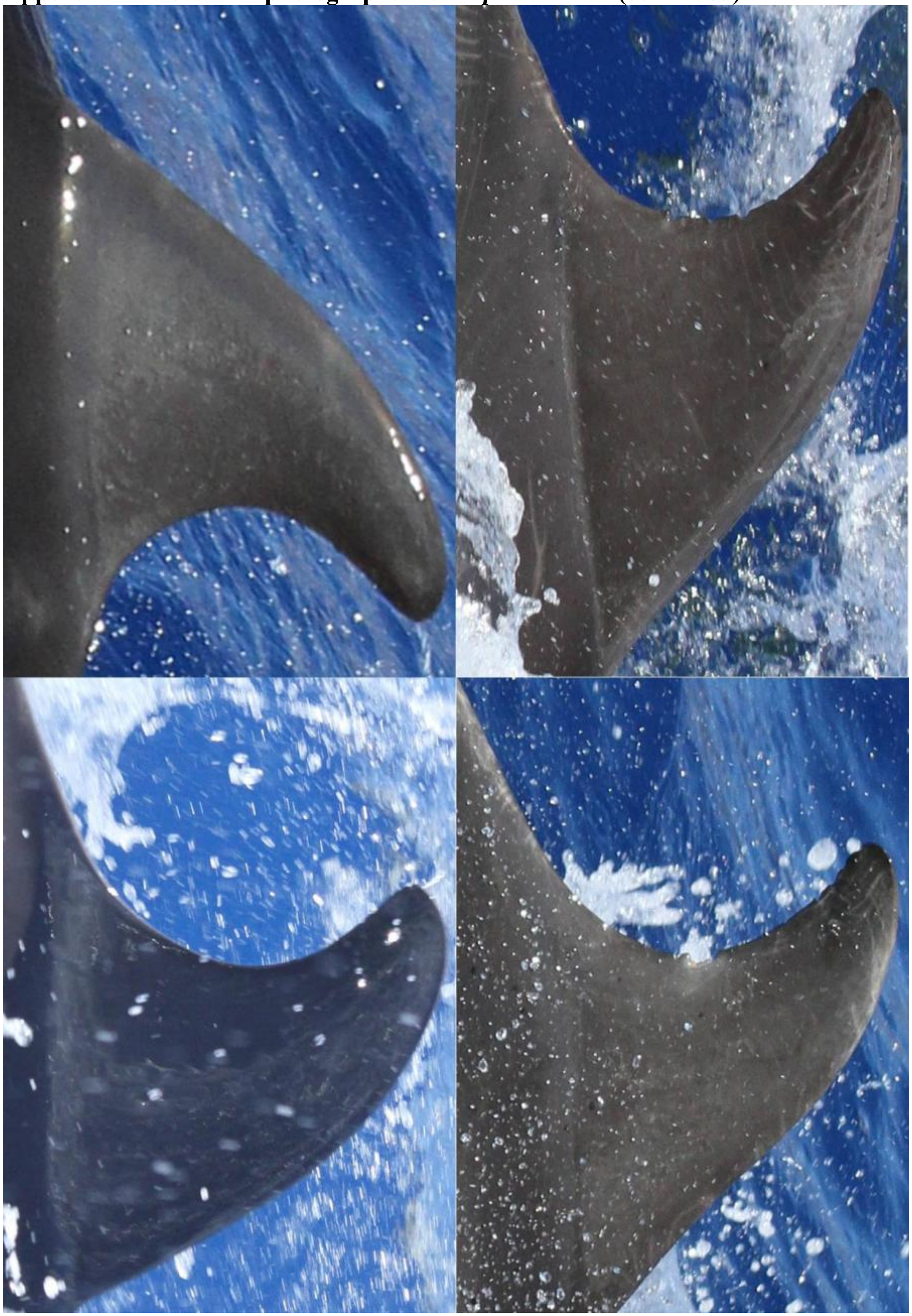
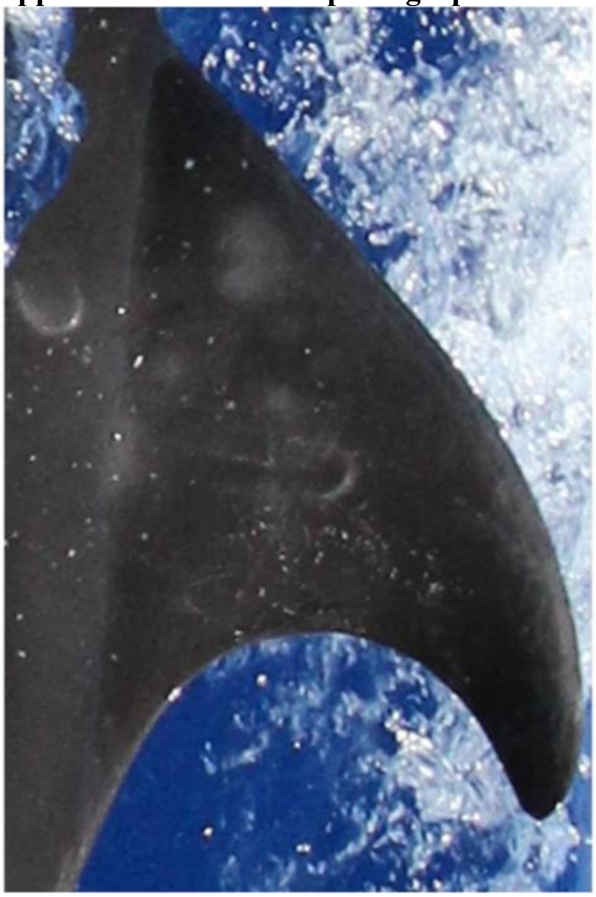
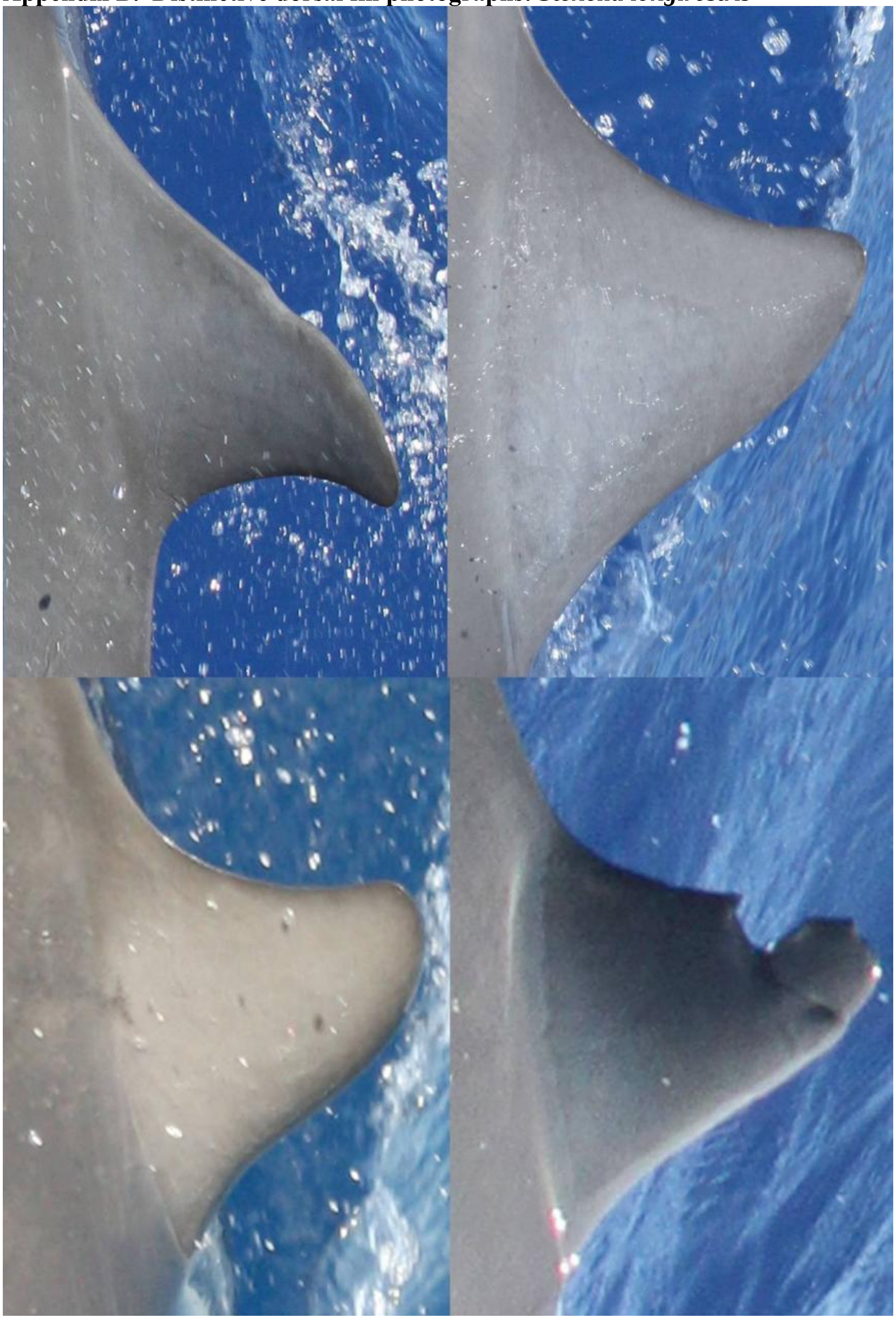


Appendix A. Dorsal fin photographs: *Tursiops truncatus* (continued)



Appendix B. Distinctive dorsal fin photographs: *Stenella longirostris*



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APPENDIX E. Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with Two Navy Training Events. SCC and USWEX February 16 - March 5, 2011. Final Field Report.

Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with two Navy Training Events

SCC and USWEX February 16 – March 5, 2011

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Acronyms and Abbreviations

DDG	missile destroyer
HD	high-definition
HRC	Hawaii Range Complex
km	kilometer
kt	knots
MFAS	Mid-frequency Active Sonar
MM/ST	Marine mammals and sea turtles
NM	Nautical Miles
NPAL	North Pacific Acoustics Laboratory
NTR	Navy Technical Representative
PMRF	Pacific Missile Range Facility
SCC	Submarine Commander's Course
SOW	statement of work
USWEX	Undersea Warfare Exercise

SECTION 1 INTRODUCTION

Aerial surveys to monitor marine mammals and sea turtles (MM/ST) were conducted in conjunction with two training events during the period February 16 to March 5, 2011, including (a) U.S. Navy Submarine Commander's Course (SCC) naval training event in the Hawaii Range Complex (HRC) on the Pacific Missile Range Facility (PMRF) instrumented range between Kauai and Niihau, Hawaii; and (b) Undersea Warfare Exercise (USWEX) training event south of Oahu and Molokai (**Figure 1**). Surveys in support of the SCC event occurred on 4 consecutive days from February 16 to 19, 2011, in waters adjoining Kauai and Niihau where the missile destroyer (DDG) and other ships were operating, followed by shoreline surveys of Kauai and Niihau on 2 separate days thereafter: February 24 and 26, 2011. This was followed by shoreline surveys of the Four Islands region in support of the USWEX event on 2 separate days, February 28 and March 5, 2011. The survey methods and sampling design were submitted and approved in advance, per the statement of work (SOW), to the Navy Technical Representative (NTR) and followed previously established protocol (Mobley and Milette 2010; Smultea et al. 2009a,b).

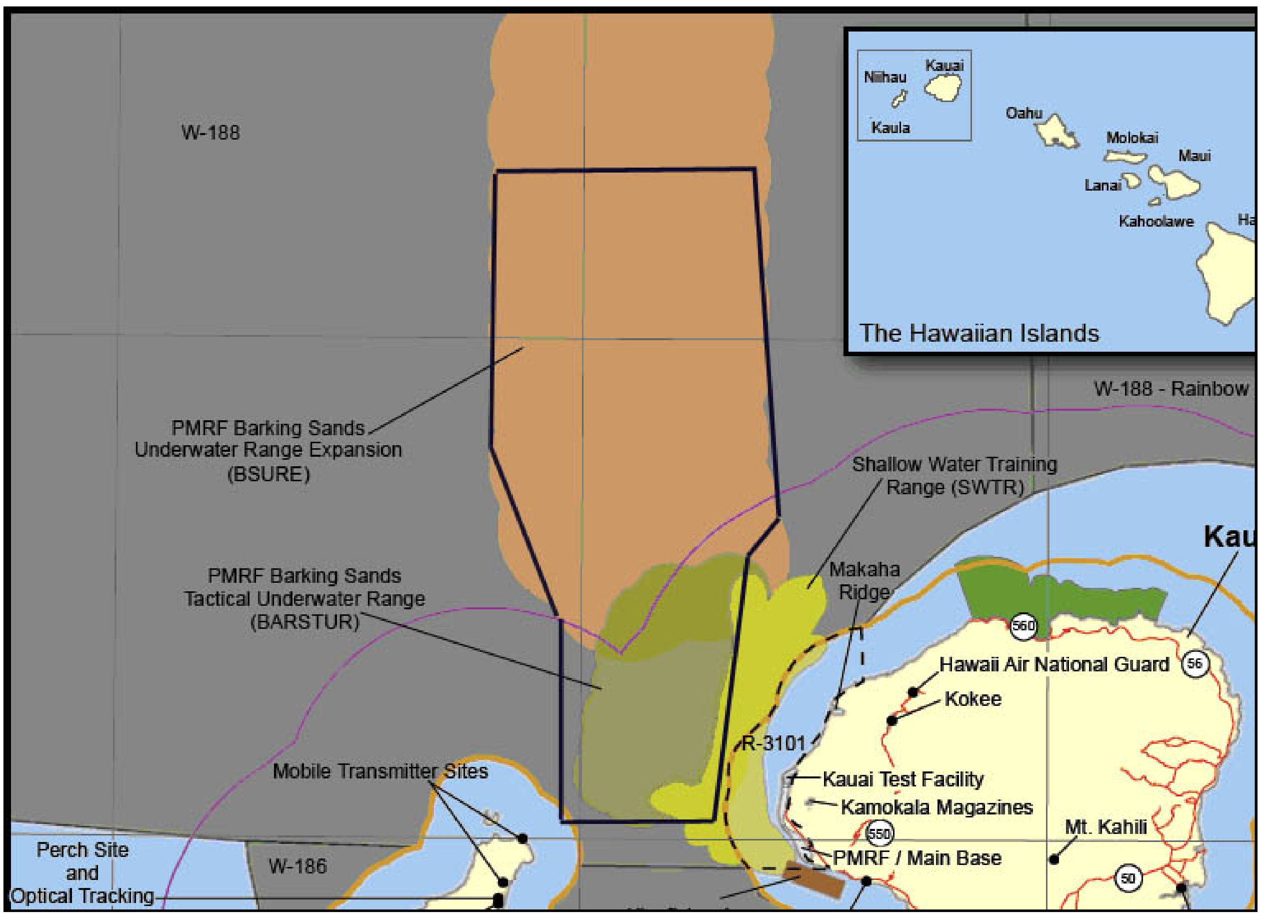

Figure 20. Location of the aerial survey monitoring area in and near the U.S. Navy PMRF Range west and northwest of Kauai, Hawaii.

Prior to the training event, the Principal Investigator (Joe Mobley) and pilot (John Sharkey) attended pre-planning sessions with the NTR and other Navy staff at Pearl Harbor, Honolulu, Oahu, Hawaii, to coordinate survey efforts with the SCC February 2011 operations. Per the SOW, the goal of the aerial survey was to monitor and report the presence/absence, distribution/redistribution, reaction/no reaction, injury, and mortality of MM/ST before, during and after the training event. This involved monitoring and reporting the surface behavior of MM/ST. In particular, we were to monitor for any changes in the near-surface behavior, orientation, occurrence, and location of animals relative to the DDG's activities using a systematic search and focal follow method.

Since mid-frequency active sonar (MFAS) locations and transmission times were unknown to the observers during this field survey effort, no effort was made to determine types or level of response of MM/ST to these transmissions. Rather, as stated in the SOW, survey data collected during this monitoring effort will be compiled with previous (Mobley and Milette 2010) and subsequent data, and analyzed by the Navy.

Survey effort during this training event was of three types (**Table 1**): (a) ship follows (February 16–18): flying elliptical orbits in front of the DDG per previous training events (Mobley and Milette 2010; Smultea et al. 2009a,b), (b) transects (February 19): flying in sawtooth pattern north of Kauai during the tagging support portion of effort, and (c) circumnavigation of islands: flying along the coastlines of Kauai and Niihau (February 24 and 26) and Four Island Region and Kona coast (February 28 and March 5) to search for stranded or near-stranded MM/STs. In all cases the mission was to document the presence of MM/STs including species identity, group composition, behavior, and any obvious reactions.

Table 1. Summary of Effort Type, Hours, and Seastate by Date.

Date	Type of Effort	No. Hrs Effort	Mean Beaufort Sea State
2/16/11	With DDG	7.8 hrs	4.4
2/17/11	With DDG	5.4 hrs	5.2
2/18/11	With DDG*	4.9 hrs	3.6
2/19/11	Transects--tag support (Cascadia)	6.4 hrs	2.9
2/24/11	Shoreline survey—Kauai/Niihau	4.2 hrs	4.0
2/26/11	Shoreline survey—Kauai/Niihau	3.8 hrs	2.4
2/28/11	Shoreline survey—Four island region and Kona coast	6.7 hrs	2.9
3/5/11	Shoreline survey—Four island region and Kona coast	4.4 hrs	2.6
TOTAL:		**46.1 hrs**	

Note: * afternoon leg on 2/18/11 cancelled due to IFR conditions (low visibility)

SECTION 2 METHODS

Monitoring effort followed protocol implemented in previous SCC training events (Mobley and Milette 2010). The approach involved flying elliptical-shaped patterns in advance of the Navy vessel (DDG) that extended from the front of the ship (~200 meters) out to ~2,500 meters) over a width of ~4 kilometers (km).

Surveys were conducted from a small fixed-wing Aero Commander flying at 100 knots groundspeed and an altitude of ~305 meters (1,000 feet), unless the pilot was directed to fly at alternate altitudes by flight controllers for safety reasons. Observations from the monitoring aircraft involved four personnel including the pilot and copilot, plus two biologist observers with one also acting as data recorder/videographer. Survey crew and pilot were not informed as to the status of MFAS transmissions, which minimized potential for observational bias. When animals were detected, the angle to the sighting was recorded using hand-held Suunto clinometers, typically followed by orbiting to identify species and in the case of marine mammals, to characterize behavior and direction of travel. Photographs were taken opportunistically by the data recorder to assist in species identification using a Canon 5D digital camera with Canon 100-400mm telephoto lens with image stabilizer. Environmental data (Beaufort seastate, glare, visibility) were recorded at the start of effort and when conditions changed. Positional data via GPS were automatically recorded every 5 seconds and manually when sightings occurred.

When pods were suitable (i.e., were visible at the surface for extended periods) focal follows were performed using accepted methods (Altmann 1974). The aircraft ascended to 457 meters (1,500 feet), an altitude shown to minimize reactivity to fixed-wing aircraft (Smultea et al. 1995), and the pod was orbited and behavior videotaped for as long as possible. A high-definition (HD) Canon Vixia HF10 camcorder with 12-power optical zoom was used to videotape focal follows. The intercom system of the aircraft inputted to the audio port of the digital camcorder so that all behavioral observations could be recorded with a minimum of ambient noise. Time stamps on the Canon camcorder were synchronized with those from the Garmin GPS receiver. The resultant digital audio/video file and digital photos will be made available to the Navy for subsequent behavioral analysis.

Overall survey effort was divided into four parts as summarized below:

(a) Ship follows, SCC event (February 16–18, 2011): involved flying elliptical orbits in front of the DDG (**Figure 2**) with the goal of finding target species in the vicinity of the DDG and observing and recording their behavior using focal follow methods (Altmann 1974)

(b) Transect surveys (February 19, 2011): to search for marine mammals in support of tagging effort by Cascadia Research Collective (**Figure 3**). Note: More detailed description of tagging effort provided in Baird et al. (2011)

(c) Circumnavigation surveys, post-SCC event (February 24 and 26, 2011): following the SCC event, the aircraft flew along the coastlines of Kauai, Niihau, and Ka‘ula islands (**Figure 3**) looking for target species along the shoreline and any stranded or near-stranded marine mammals

(d) Circumnavigation surveys, post-USWEX event (February 28 and March 5, 2011): following the USWEX training event, the aircraft flew along the coastlines of Oahu, the Four Island Region (Maui, Molokai, Lanai, and Kahoolawe), and the Kona coast of the island of Hawaii (**Figure 4**).

Most sightings during the 3-day SCC event occurred during transits between Lihue, Kauai, and the ship's position **(Figure 2)**. Four sightings of humpback whales occurred in the vicinity of the DDG (four squares shown in elliptical plots), one of which became the target of a focal follow session with videotape.

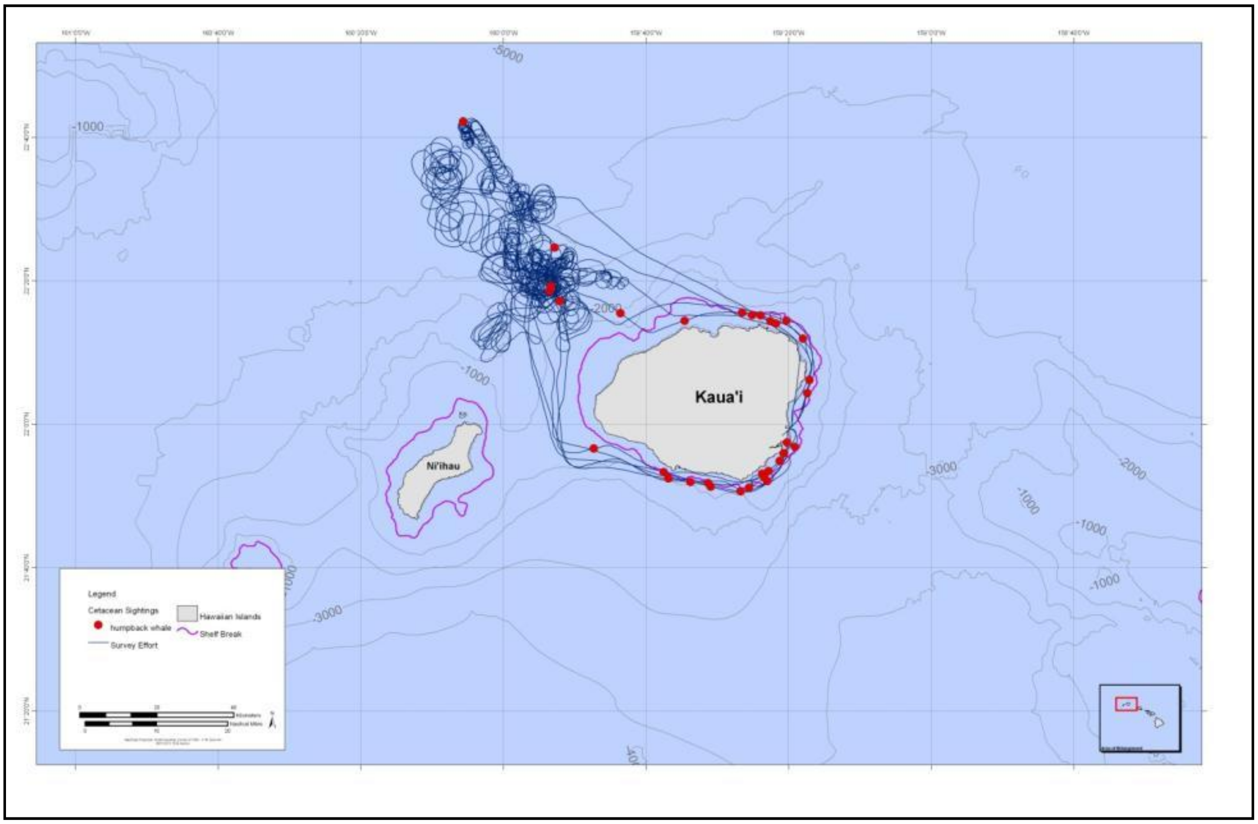

Figure 2. Effort and sighting locations during days involving ship follows with the DDG (February 16–18, 2011). All marine mammal sightings are of humpback whales.

Aerial support of the tagging effort followed a sawtooth transect pattern north of Kauai (**Figure 3**). The shoreline survey effort involved circumnavigating the islands of Kauai and Niihau approximately 1 to 2 km offshore.

Communications

Communications were reliably established between the survey aircraft and the DDG using aviation-band VHF radios broadcasting on 123.45 MHz. Observers onboard the DDG used a handheld aviation VHF radio while on the bridge wing of the DDG. This system proved to be reliable whenever the aircraft was in the vicinity of the ship (i.e., < 10 km); whereas communications at greater distances were possible via radio communications with PMRF Range Control or Outrider Bravo. Daily locations of the DDG were usually communicated via onboard VHF radio once in the air via PMRF Range Control or Outrider Bravo.

Range Control Interventions

Range safety during training events is of paramount importance. Range control interventions during the SCC training event occurred more frequently than in past SCC observation missions (**Table 2**).

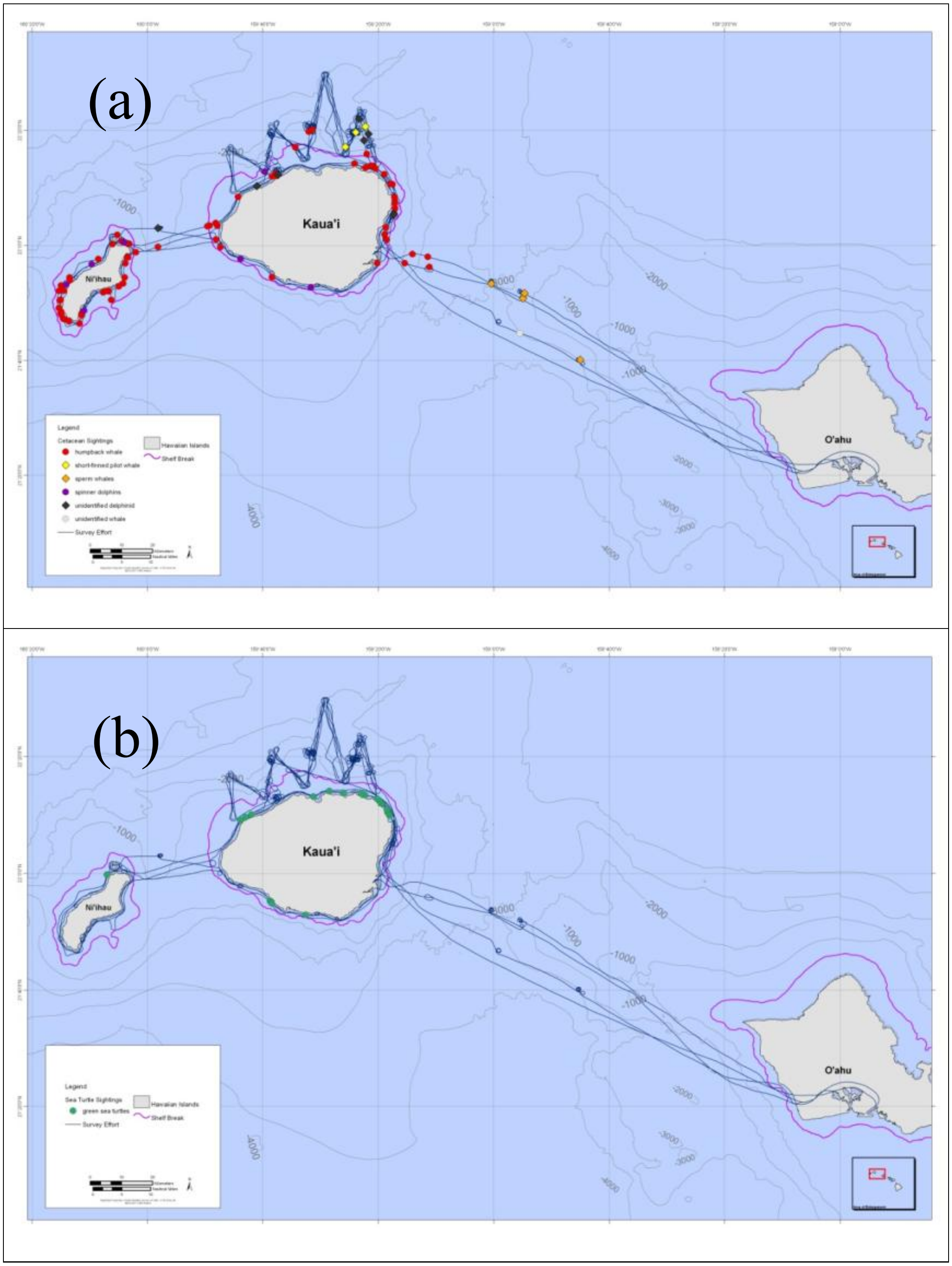

Figure 3. Post-SCC event. Effort and sighting locations during spotting assist for tagging effort (Feb. 19) and circumnavigation of Kauai and Niihau (February 24 and 26, 2011). Marine mammal sightings are shown in (a) and sea turtle sightings are shown in (b).

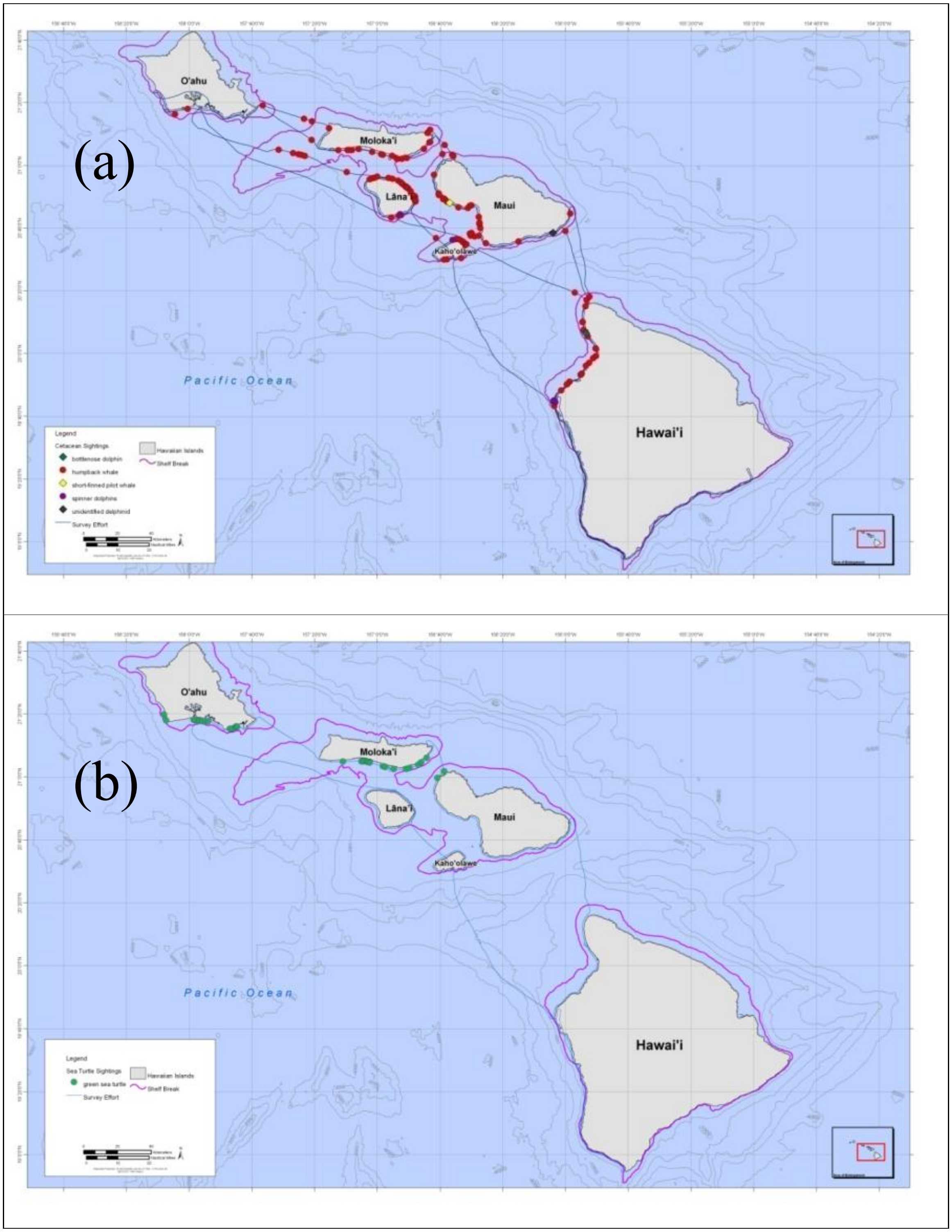

Figure 4. Post USWEX event. Effort and sighting locations during shoreline surveys of Oahu, Molokai, Maui, Lanai, Kahoolawe, and Kona coasts. Marine mammal sightings are shown in (a) and sea turtle sightings are shown in (b).

Table 2. Summary of Range Control Interventions

Date	Time	Instruction
Feb 16	15:06	Directed away from DDG by Range Control; returned 26 minutes later at 15:32.
Feb 17	08:02	Instructed to stay within 2 Nautical Miles (NM) of DDG location at all times. This did not permit focal follows since theyfrequently requires moving more than 2 NM away from DDG
Feb 17	09:15	Instructed to orbit south of DDG location; allowed to return 1 hour 20 minutes later (called twice during intervening period but no reply).
Feb 18	11:00	Instructed to stay south of 22°26' latitude which required leaving DDG. Were able to return to DDG at 11:33 and remained in contact until 14:18.

SECTION 3 RESULTS

Effort

During the SCC event (February 16–18), the survey aircraft accompanied the DDG for 13.25 hours (66%) of the total 19.95 hrs of SCC-related flight time (**Table 3**). The remaining 6.7 hours (34%) while not with the DDG primarily involved transiting between the DDG's location and Lihue, Kauai, and maintaining a holding pattern per the instructions of PMRF Range Control (**Figure 2**). The aircraft was considered "with the DDG" upon commencement of elliptical orbits around the ship's location (**Figure 2**).

On February 19, the mission was to provide aerial spotting services to support a tagging operation (Cascadia Research Collective aboard the M/V Searcher) north of Kauai. Effort followed a sawtooth transect pattern (**Figure 3**) Note: More detail of tagging effort is provided in Baird et al. (2011).

Shoreline surveys were conducted as part of the SCC event in the waters surrounding Kauai/Niihau (February 24 and 26) (**Figure 3**) and in conjunction with the USWEX event in waters south of the eastern portion of the main Hawaiian Island chain (February 28 and March 5) (**Figure 4**).

Sea State

The majority of overall effort (70%) was spent in good sea state conditions (i.e., Beaufort 1-3) (**Figure 5**). The majority of sightings (57%) occurred in these more favorable conditions, with most in Beaufort 2. This pattern is consistent with known effects of sea state on sighting probabilities (Buckland et al. 2001).

Table 3. Survey Effort (with and not with DDG).

Date	Time Wheels Up	Time Wheels Down	Total Flight Hours	Period not with DDG	Total Hours not with DDG	Period with DDG	Total Hours with DDG	No. Sightings With DDG	No. Sightings Away from DDG
2/16/2011	7:35 13.15	12:03 16.25	4.28 3.10	7:351–8:05 11:32–12:03 13:15–13:37 15:06–15:32 16:00–16:25	2:14	8:05–11:32 13:37–15:06 15:32–16:00	5:24	2	12
2/17/2011	7:41 13.32	11:55 16:44	4:14 3:12	7:41–8:02 9:15–10:40 11:30–11:55 13:32–13:45 16:15–16:44	2:53	8:02–9:15 10:40–11:30 13:45–16:15	4:33	1	11
2/18/2011	9:55	14:48	4:53	9:55–10:27 11:00–11:33 14:18–14:48	1:35	10:27–11:00 11:33–14:18	3:18	1	5
2/19/2011	7:47 13:18	11:50 15:51	4:03 2:33	7:47–11:50 13:18–15:51	6:36	n/a	n/a	n/a	18
2/24/2011	8:07 12:10	11:32 13:04	3:25 0:54	8:07–11:32 12:10–13:04	4:19	n/a	n/a	n/a	41
2/26/2011	7:50 12:04	10:34 13:00	2:44 0:56	7:50–10:34 12:04–13:00	3:40	n/a	n/a	n/a	60
2/28/2011	7:54 13:34	12:22 15:40	4:28 2:06	7:54–12:22 13:34–15:40	6:34	n/a	n/a	n/a	91
3/5/2011	7:37 12:00	10:45 13:53	3:08 1:53	7:37–10:45 12:00–13:53	5:01	n/a	n/a	n/a	63
Total			**46:07**		**32:52**		**13:15**	**4**	**301**

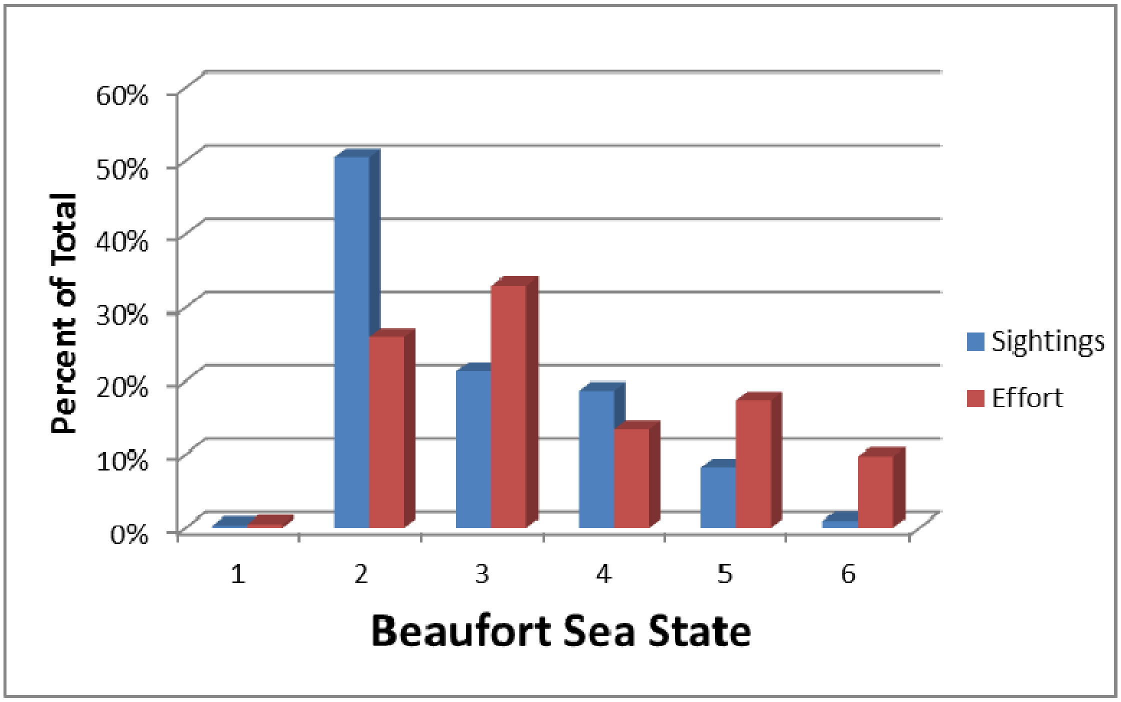

Figure 5. Beaufort sea state conditions for total effort and for sightings.

Sightings

There were 305 sightings made during the 8 days of surveys (**Table 4**). The majority (74%) of these sightings were of humpback whales observed in shallow areas (< 1,000 fathoms), known to be preferred habitat of humpbacks based on past survey results (Mobley 2004). Of the 227 sightings of humpback whales, 195 were seen during the transect and shoreline surveys (i.e., not including those seen during ship follows). When converted to sighting rates, the result is 0.040 humpback sightings/km effort. This represents twice the sighting rate for humpbacks seen north of Kauai during the 2006 North Pacific Acoustics Laboratory (NPAL) surveys—0.020 humpback sightings/km effort (Mobley 2006). The greater rate of humpback whale sightings recorded during the present surveys is consistent with previous reports of increases in the Hawaii wintering population (Mobley et al. 1999, Mobley 2004, Calambokidis et al. 2008).

The remaining sightings with confirmed species identifications consisted of odontocete species, specifically spinner dolphins, bottlenose dolphins, short-finned pilot whales, and sperm whales. All of these are typically found in Hawaiian waters (Mobley et al. 2000, Barlow 2006). Twenty-nine odontocete sightings were recorded during all of the non-ship follow surveys combined and this converts to a sighting rate of 0.004 odontocete sightings/km effort. This is less than the sighting rate of 0.006 odontocetes/km effort reported for transect surveys of the main Hawaiian Islands conducted in 2000 (Mobley 2004). However, when restricted to the 22 odontocete sightings that occurred during non-ship follow surveys in the Kauai/Niihau area (February 19, 24, and 26), this results in a sighting rate of 0.008 odontocete sightings/km effort. This is more than the 0.006 sightings/km effort reported for the Kauai region during 2002 surveys on the PMRF instrumented range (Mobley 2004).

Table 4. Summary of Sightings for Kauai-Niihau Shoreline surveys (Feb. 19, 24, 26).

Species	Region	No. Groups	No. indiv's
Green sea turtles	Kauai	20	35
	Niihau	1	1
Humpback whales	Kauai	37	71
	Niihau	39	60
Short-finned pilot whales	Kauai	4	35
Sperm whales	Kauai Channel	4	14
Spinner dolphins	Kauai	3	132
	Niihau	4	360
Unid. delphinid spp.	Kauai	5	33
	Niihau	1	11
Unid. whale spp.	Channel	1	3
	Total:	**119**	**755**

We recorded 48 sightings of green sea turtles, all of which were observed in the shallow coastal waters where the animals were highlighted against the light sandy bottom (**Figures 3** and **4**). Thus, these numbers are likely an undercount of sea turtle species given the limited range of conditions under which they were observed. The 48 sightings of sea turtles recorded during the non-ship follow surveys produces a sighting rate of 0.010 sea turtle sightings/km effort. Since this is the first encounter rate estimate for this species as part of HRC monitoring, there is no basis for comparison.

Although Hawaiian monk seals were recorded on previous surveys in this region (Smultea et al. 2009a), no monk seals were seen during this survey series either swimming or hauled out onshore. Given the relatively low numbers of monk seals in the main Hawaiian Islands (Baker and Thompson 2007), the absence of this species likely reflects a random sampling artifact rather than a systematic effect.

Observations across the 8 days of survey effort revealed no evidence of injury or mortality among target species before, during, and after the event. There were no behavioral indications of distress (e.g., tight aggregations of pod members) or unusual nearshore aggregations of marine mammals. The circumnavigation of islands (February 24, 26, and 28; and March 5) similarly revealed no stranded or near-stranded animals. Evidence regarding possible effects is further summarized in the next section.

Four sightings of humpback whales occurred in the vicinity of the DDG (**Table 5; Figure 1**). One of these pods became the subject of a focal follow session described in the next section.

Table 5. Summary of Sightings for Post-USWEX Event Shoreline Surveys (Feb 28, Mar 5)—No. Groups (No. Indiv's).

Region	Species					
	Green sea turtles	Bottlenose dolphins	Humpback Whales	Short-finned pilot whales	Spinner dolphins	Unid. Delphinid spp.
Oahu	11 (20)		3 (7)			
Penguin Bank			10 (14)			
Molokai	14 (37)		17 (31)			
Lanai			26 (38)		1 (50)	
Kahoolawe			14 (21)		3 (92)	1 (3)
Maui	2 (2)	1 (5)	26 (36)	1 (2)		
Big Island			24 (40)			
Total: 154 (398)	**27 (59)**	**1 (5)**	**120 (187)**	**1 (2)**	**4 (142)**	**1 (3)**

Behavioral Focal Follows

Behavioral focal follows were conducted during the SCC event (February 16–18) while circling at an altitude of ~1,400 to 1,500 feet and a lateral distance of ~1 km (summarized in **Table 6**). The higher altitude for focal follows was designed to reduce the potential for reactivity to plane engine noise, thereby permitting naturalistic observation of whales in the vicinity of the DDG (Smultea et al. 1995).

Humpback whale pods were seen within the vicinity of the DDG (≤ 5 km) on four occasions during the SCC event (**Table 6**) but a focal follow was initiated in only one instance. In two of the other three instances the target pod was not resighted after initial detection and in one instance, the observation plane was directed away from the sighting by Outrider Bravo control to deconflict aircraft operations in the area.

The one behavioral focal follow session conducted while monitoring near the DDG (February 18; **Appendix C**) involved a pod of two humpback whales. At closest proximity, the pod was found within 1 to 2 km of the ship, and was observed for a total period of approximately 32 minutes; however, the whales were not in view the entire time due to the orientation of the plane or when the pod was traveling underwater. During surface observations, no obvious indications of stress were seen, i.e., the animals did not assume a defensive posture nor did they dive quickly, though, as noted earlier, any specific response to MFAS could not be determined since the observers were unaware of sonar transmission status throughout the event. However, the animals remained within 2 to 4 km of the DDG for most of the 32-minute observation period, suggesting that the activities and presence of the ship were not overly disturbing.

During the focal follow, behavior was called out in real time and recorded onto the audio of the digital videocam. The digital video files and the still photos will be made available to the Navy for subsequent behavioral analysis.

Table 6. Summary of Sightings by Species—All Surveys Combined.

Species	No. Groups	No. Indiv.	Ave. Pod Size
Humpback Whales (*Megaptera novaeangliae*)	227	370	1.63
Green Sea Turtle (*Chelonia mydas*)	48	95	1.98
Spinner Dolphins (*Stenella longirostris*)	11	634	57.64
Unidentified Dolphin	8	54	6.75
Short-finned Pilot Whale (*Globicephala macrorhynchus*)	5	37	7.40
Sperm Whale (*Physeter macrocephalus*)	4	14	3.50
Unidentified Whale	1	3	3.00
Bottlenose Dolphin (*Tursiops truncatus*)	1	5	5.00
Total	**305**	**1,212**	**-**

Table 7. Summary of sightings with and away from the DDG--All Surveys Combined.

Species	With the DDG		Away from the DDG		Total	
	No. Grps	No. Indiv.	No. Grps	No Indiv.	No. Grps	No. Indiv.
Humpback Whale (*Megaptera novaeangliae*)	4	5	223	365 (16 calves)	227	370 (16 calves)
Bottlenose Dolphin (*Tursiops truncatus*)	0	0	1	5	1	5
Short-finned Pilot Whale (*Globicephala macrorynchus*)	0	0	5	37 (1 calf)	5	37 (1 calf)
Spinner Dolphin (*Stenella longirostris*)	0	0	11	634 (1 calf)	11	634 (1 calf)
Sperm whale (*Physeter macrocephalus*)	0	0	4	14 (4 calves	4	14 (4 calves)
Unidentified Dolphin (Delphinidae)	0	0	8	54	8	54
Unidentified Whale	0	0	1	3	1	3
Green Sea Turtle (*Chelonia mydas)*	0	0	48	95	48	95
Total	**4**	**5**	**301**	**1,207**	**305**	**1,212**

Table 8. Summary of Pods Observed within 5 km of DDG (February 16–18)

Date	Time Sighted	Species	No. Individuals	Video? (Y/N)	If No, Reason Video not Initiated
Feb 16	14:05	Humpback Whale (MN)	1	N	Not resighted*
Feb 16	14:12	MN	1	N	Not resighted*
Feb 17	08:11	MN	1	N	Directed away from location by Outrider Bravo
Feb 18	13:14	MN	2	Y	

Note: *Also sighted by observers onboard DDG.

SECTION 4 DISCUSSION

As stated in the SOW, the survey mission was to "monitor and report the presence/absence, distribution/redistribution, reaction/no reaction, injury, and/or mortality of marine mammals and sea turtles before, during and after the event." Evidence regarding each of these points is summarized below:

(a) Presence/absence. This category is best assessed using an aggregate index such as "overall sightings per km" reported earlier. The observed sighting rates for humpbacks (0.040 sightings/km) suggest that humpbacks were present in the target area at higher densities than previously reported for this area (0.020 sightings/km) (Mobley 2006 for period mid-Feb through late-March), consistent with reports of an increasing winter population (Calambokidis et al. 2008, Mobley 2004). The overall sighting rate for odontocetes (0.004 sightings/km) for all non-ship-follow surveys was lower than that reported earlier from transect surveys of the main Hawaiian Islands in 2000 (0.006 sightings/km) with no training events ongoing (Mobley 2004). However, when the analysis was restricted to the Kauai/Niihau region where training events were closer to the surveyed regions involved, the sighting rate for odontocetes (0.008 sightings/km) was higher than that seen earlier during 2002 surveys of the same region with no training events ongoing (0.006 sightings/km) (Mobley 2004). This suggests that the training events did not result in the evacuation of the area on the part of odontocetes.

(b) Distribution/redistribution. The same principle described in (a) applies to assessing changes in distribution, i.e., changes in distribution can only be reliably detected for the most abundant species, e.g., seasonally present humpbacks via comparisons across consecutive seasons (e.g., Mobley 2005). If one examines the locations of humpbacks observed in this survey series (**Figures 2** through **4**), it is clear that they were seen throughout their normal preferred habitat of shallow, coastal regions as shown in previous surveys (e.g., Mobley 2004). In contrast, since the distribution of odontocetes is typically sparse, particularly for tropical waters such as Hawaii (Barlow 2006), discerning distribution change is made difficult. Sea turtles are also sparsely distributed, and only seen occasionally along primarily sand-bottom coastal regions (see Recommendations), so it is similarly difficult to discern changes in distribution for these species.

(c) Reaction/no reaction. For this category one must be able to distinguish reactions to the observation platform (survey aircraft in this case) from reactions related to the training event (e.g., MFAS). For that reason, the best source of data would be to aggregate the focal follow observations across multiple trials based on observations from non-reactive platforms (e.g., aircraft altitude ≥ 457 meters). That way one can discern changes in respiration rates, dive times, and other factors that might correlate with MFAS transmissions with little or no reactivity to the platform itself. To that end, we will continue to provide Navy sponsors with videotaped results of focal follows and detailed behavioral logs (**Appendix C**).

(d) Injury and mortality. Injury and mortality are readily discernible for each of the target species due to marked reduction or cessation of locomotion and by other cues, such as visible wounds or blood. As such, it is arguably the most detectible of the four categories listed here. There was no evidence of injury or mortality for any of the target species observed before, during, or after either of the two training events.

Given the caveats noted, overall there were no direct observations of adverse effects of the training event. As for the effects of sonar, since the status of MFAS transmissions throughout the survey period was unknown, any specific response of the animals observed to such transmissions would require more detailed behavioral analyses by the Navy with knowledge of the time/duration of MFAS. The time-stamped audio/video files from the focal follows will be provided to the Navy to enable such detailed analyses. Per the SOW, the data obtained in this study are meant to contribute to a growing baseline of information on the distribution, occurrence, and behavior of MM/ST near Navy training events in the HRC per the HRC marine species monitoring plan (DoN 2008) and as revised in the Pacific Fleet Annual Monitoring Report (DoN 2009).

SECTION 5 RECOMMENDATIONS

In light of the issues summarized in this report, the following recommendations are offered:

(1) Promote development of baseline behavior and density database for more abundant species (e.g., humpback whales, spinner dolphins). Discerning effects of MFAS or any other training event-related stimulus requires comparisons with baseline behavior and densities particularly for the more abundant species where sufficient statistical power can be more readily obtained. For the HRC, the more abundant species include the seasonally present humpbacks and the spinner dolphins that are present year-round (Mobley 2004). It is recommended that the Navy consider promoting the development of these databases to facilitiate such comparisons.

(2) Consider limiting sea turtles as target species for coastal surveys only since they can only be reliably detected along coastlines with primarily sandy bottoms. Sea turtles are rarely observed during open ocean surveys.

(3) Consider revising goal of detecting "presence/absence" to focus primarily on aggregate indices such as sighting rates (e.g., sightings/km) of highly abundant species (e.g., humpback whales) or combined sightings of remaining species (e.g., odontocetes). For reasons noted previously, applying a presence/absence criterion on a species by species basis, except for the most abundant species, is not a defendable approach.

(4) Consider revising goal of detecting "redistribution" to focus similarly on more abundant species (e.g., humpbacks) where changes in distribution are more readily discernible.

(5) Consider briefing Range Control officers concerning the mission of the marine mammal monitoring team. The Range Control interventions during this event were more disruptive of the marine mammal monitoring effort than occurred in the past (**Table 6**). It is likely that the level of disruption could be reduced by briefing those involved in directing range activities as to the mission and protocols involved in the monitoring effort.

SECTION 6 ACKNOWLEDGEMENTS

We are grateful to Navy personnel from U.S. Pacific Fleet Environmental (N01CE1) and Naval Facilities Engineering Command Pacific EV24 (NAVFAC PAC) for their support, coordination, and facilitation in the implementation of these surveys. Many thanks to my fellow observer, Lenisa Blair and to our pilot team consisting of Matt Dornan, Jeff Kinyon, Nakana Rivera, and John Sharkey. All observations were made in accordance with NOAA permit no. 14451 issued to Joseph R. Mobley, Jr.

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APPENDIX A

Summary of Sightings with Positions (GPS)

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/16/2011	7:40:01	MN	2	21	52.08	159	22.963
2/16/2011	7:42:01	MN	1	21	53.1	159	23.692
2/16/2011	13:17:01	MN	2	21	57.465	159	20.192
2/16/2011	13:18:01	MN	3	21	55.946	159	20.624
2/16/2011	13:20:01	MN	1	21	52.54	159	23.356
2/16/2011	13:21:01	MN	1	21	51.165	159	25.53
2/16/2011	13:23:01	MN	1	21	51.298	159	30.911
2/16/2011	13:24:01	MN	1	21	51.95	159	33.738
2/16/2011	13:25:01	MN	1	21	52.431	159	36.847
2/16/2011	14:05:01	MN	1	22	18.581	159	53.454
2/16/2011	14:12:01	MN	1	22	19.297	159	53.317
2/16/2011	16:13:01	MN	2	22	15.213	159	25.088
2/16/2011	16:14:10	MN	3	22	14.382	159	22.497
2/16/2011	16:14:31	MN	2	22	14.07	159	21.772
2/17/2011	7:43:58	MN	2	21	56.83	159	19.079
2/17/2011	7:49:58	MN	3	21	50.643	159	26.704
2/17/2011	8:10:58	MN	1	22	24.634	159	52.77
2/17/2011	11:37:58	MN	1	22	15.48	159	43.551
2/17/2011	11:41:58	MN	2	22	14.42	159	34.547
2/17/2011	11:44:58	MN	1	22	15.571	159	26.484
2/17/2011	11:45:58	MN	1	22	15.166	159	23.908
2/17/2011	11:48:58	MN	1	22	11.931	159	17.959
2/17/2011	11:51:58	MN	1	22	6.182	159	17.049
2/17/2011	13:38:58	MN	1	21	51.787	159	31.269
2/17/2011	16:33:58	MN	2	22	14.447	159	20.262
2/17/2011	16:39:58	MN	1	22	4.352	159	17.363
2/18/2011	9:58:02	MN	4	21	54.874	159	21.214
2/18/2011	9:59:02	MN	1	21	53.479	159	22.798
2/18/2011	10:07:02	MN	2	21	53.324	159	37.495
2/18/2011	10:12:02	MN	2	21	56.602	159	47.303

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/18/2011	10:22:02	MN	2	22	17.158	159	52.081
2/18/2011	13:13:59	MN	2	22	42.253	160	5.611
2/19/2011	7:49:58	MN	1	22	1.902	159	18.875
2/19/2011	7:52:58	MN	1	22	8.441	159	17.2
2/19/2011	7:53:58	MN	2	22	10.628	159	17.539
2/19/2011	7:54:58	MN	1	22	12.376	159	18.921
2/19/2011	7:55:58	MN	1	22	13.86	159	20.829
2/19/2011	7:56:58	MN	2	22	15.922	159	21.968
2/19/2011	8:06:58	GM	4	22	19.662	159	23.906
2/19/2011	9:49:58	MN	1	22	17.086	159	34.371
2/19/2011	10:45:58	MN	4	22	19.789	159	32.044
2/19/2011	10:55:58	MN	4	22	20.138	159	31.405
2/19/2011	10:56:03	GM	10	22	20.142	159	31.577
2/19/2011	13:24:58	MN	3	22	7.598	159	17.097
2/19/2011	13:39:02	GM	18	22	20.67	159	22.262
2/19/2011	13:42:02	UD	3	22	21.979	159	23.34
2/19/2011	14:20:02	SL	35	22	12.839	159	39.71
2/19/2011	15:28:02	GM	4	22	17.143	159	25.713
2/19/2011	15:35:01	UD	3	22	19.389	159	21.706
2/24/2011	8:46:00	MN	2	22	1.013	159	18.517
2/24/2011	8:47:00	MN	2	22	3.12	159	18.65
2/24/2011	8:51:00	MN	2	22	10.723	159	17.906
2/24/2011	8:53:00	MN	2	22	13.386	159	20.45
2/24/2011	8:53:30	MN	3	22	13.848	159	21.282
2/24/2011	9:02:00	MN	3	22	12.004	159	38.393
2/24/2011	9:05:00	MN	1	22	8.442	159	44.295
2/24/2011	9:08:00	MN	1	22	3.382	159	47.868
2/24/2011	9:15:00	MN	2	21	59.758	159	58.163
2/24/2011	9:19:00	MN	1	22	1.833	160	5.216
2/24/2011	9:26:00	MN	3	21	57.628	160	8.499
2/24/2011	9:29:00	MN	1	21	54.438	160	13.511
2/24/2011	9:30:00	MN	2	21	53.035	160	14.993
2/24/2011	9:30:30	MN	1	21	52.094	160	15.312

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/24/2011	9:32:00	MN	2	21	49.113	160	15.361
2/24/2011	9:32:30	MN	1	21	48.154	160	15.036
2/24/2011	9:33:00	MN	1	21	47.234	160	14.615
2/24/2011	9:35:00	MN	1	21	46.403	160	11.755
2/24/2011	9:36:00	MN	2	21	47.923	160	11.448
2/24/2011	9:36:30	SL	110	21	48.677	160	10.998
2/24/2011	9:45:00	MN	1	21	51.83	160	7.669
2/24/2011	9:45:30	MN	1	21	52.028	160	6.692
2/24/2011	9:47:00	MN	2	21	53.39	160	4.194
2/24/2011	9:50:00	MN	3	21	57.984	160	3.5
2/24/2011	9:53:00	MN	1	22	0.244	160	6.052
2/24/2011	9:58:00	MN	1	21	54.003	160	13.396
2/24/2011	9:59:00	MN	1	21	52.588	160	14.77
2/24/2011	10:00:00	MN	1	21	50.559	160	15.036
2/24/2011	10:16:00	MN	1	21	58.839	160	1.995
2/24/2011	10:29:00	CM	1	21	55.28	159	38.745
2/24/2011	10:29:10	CM	1	21	55.039	159	38.551
2/24/2011	10:34:00	CM	5	21	52.887	159	32.575
2/24/2011	10:34:30	SL	12	21	52.74	159	31.64
2/24/2011	10:55:00	CM	1	22	10.463	159	18.378
2/24/2011	10:58:00	MN	2	22	13.514	159	22.226
2/24/2011	11:00:00	CM	1	22	13.83	159	26.023
2/24/2011	11:06:00	MN	4	22	12.475	159	37.794
2/24/2011	11:20:00	CM	4	21	54.854	159	38.421
2/24/2011	12:26:02	UW	3	21	44.725	158	55.448
2/24/2011	12:31:02	PM	3	21	40.113	158	45.01
2/26/2011	8:35:30	MN	4	21	56.244	159	11.143
2/26/2011	8:39:30	MN	2	21	56.923	159	15.397
2/26/2011	8:45:30	UD	20	22	5.442	159	17.363
2/26/2011	8:45:33	MN	2	22	5.372	159	17.306
2/26/2011	8:54:09	MN	2	22	6.446	159	17.068
2/26/2011	8:54:36	MN	2	22	7.355	159	17.124
2/26/2011	8:55:06	MN	2	22	8.344	159	17.139

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/26/2011	8:56:03	CM	1	22	9.934	159	17.991
2/26/2011	8:56:18	CM	2	22	10.354	159	18.266
2/26/2011	8:56:36	CM	3	22	10.922	159	18.481
2/26/2011	8:57:18	CM	1	22	11.939	159	19.333
2/26/2011	8:57:21	CM	2	22	11.998	159	19.415
2/26/2011	8:57:39	CM	2	22	12.448	159	19.818
2/26/2011	8:57:54	CM	3	22	12.802	159	20.172
2/26/2011	8:58:57	CM	1	22	13.417	159	22.265
2/26/2011	8:59:18	CM	1	22	13.729	159	22.933
2/26/2011	8:59:54	MN	2	22	14.25	159	24.096
2/26/2011	9:02:03	CM	2	22	14.124	159	28.504
2/26/2011	9:03:45	CM	1	22	13.161	159	31.217
2/26/2011	9:07:12	UD	3	22	12.282	159	37.36
2/26/2011	9:10:03	MN	2	22	12.073	159	37.612
2/26/2011	9:12:09	UD	7	22	10.324	159	41.065
2/26/2011	9:12:39	CM	1	22	10.088	159	41.991
2/26/2011	9:13:15	CM	1	22	9.647	159	43.01
2/26/2011	9:13:49	CM	1	22	9.199	159	43.926
2/26/2011	9:17:42	MN	1	22	3.89	159	48.164
2/26/2011	9:18:27	MN	1	22	3.346	159	49.591
2/26/2011	9:25:42	MN	2	22	0.289	160	3.166
2/26/2011	9:26:09	SL	175	22	0.564	160	4.029
2/26/2011	9:26:12	MN	2	22	0.588	160	4.125
2/26/2011	9:32:36	CM	1	21	59.774	160	7.022
2/26/2011	9:34:57	SL	40	21	56.751	160	9.656
2/26/2011	9:39:06	SL	50	21	53.215	160	14.078
2/26/2011	9:39:45	MN	2	21	52.138	160	14.486
2/26/2011	9:40:48	MN	2	21	50.443	160	15.213
2/26/2011	9:41:57	MN	2	21	48.444	160	14.921
2/26/2011	9:43:27	MN	2	21	47.935	160	14.891
2/26/2011	9:43:57	MN	2	21	47.156	160	14.316
2/26/2011	9:44:24	MN	2	21	46.796	160	13.59
2/26/2011	9:46:06	MN	1	21	47.848	160	11.365

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/26/2011	9:49:24	MN	2	21	52.085	160	7.002
2/26/2011	9:50:21	MN	2	21	50.533	160	6.279
2/26/2011	9:52:15	MN	1	21	52.897	160	4.956
2/26/2011	9:53:24	MN	1	21	54.426	160	3.947
2/26/2011	9:54:45	MN	1	21	56.874	160	3.812
2/26/2011	9:55:21	MN	3	21	57.929	160	3.353
2/26/2011	9:56:57	MN	2	22	0.338	160	3.471
2/26/2011	9:57:27	MN	1	22	0.736	160	4.435
2/26/2011	10:02:45	UD	11	22	3.02	159	58.193
2/26/2011	10:11:51	MN	2	22	1.034	159	48.121
2/26/2011	10:12:48	MN	2	21	59.735	159	47.343
2/26/2011	10:17:42	SL	85	21	57.625	159	43.858
2/26/2011	10:23:39	MN	1	21	54.49	159	38.394
2/26/2011	10:34:03	MN	1	21	56.906	159	20.155
2/26/2011	12:07:49	MN	1	21	58.513	159	14.067
2/26/2011	12:09:07	MN	1	21	58.033	159	11.401
2/26/2011	12:15:22	PM	6	21	53.354	159	0.407
2/26/2011	12:24:22	PM	2	21	50.804	158	54.934
2/26/2011	12:26:04	PM	3	21	51.683	158	54.636
2/28/2011	8:05:06	CM	2	21	19.901	158	7.999
2/28/2011	8:07:39	MN	3	21	16.405	158	4.48
2/28/2011	8:09:27	CM	2	21	18.017	158	7.309
2/28/2011	8:15:03	MN	2	21	18.05	158	0.434
2/28/2011	8:16:00	CM	1	21	18.191	157	58.495
2/28/2011	8:16:21	CM	1	21	18.064	157	57.783
2/28/2011	8:17:24	CM	3	21	17.728	157	55.653
2/28/2011	8:18:12	CM	3	21	17.669	157	54.005
2/28/2011	8:22:09	CM	1	21	15.326	157	46.958
2/28/2011	8:23:12	CM	1	21	16.077	157	44.966
2/28/2011	8:28:48	MN	2	21	19.185	157	36.516
2/28/2011	8:35:15	MN	2	21	14.914	157	23.331
2/28/2011	8:36:30	MN	1	21	14.077	157	20.827
2/28/2011	8:39:30	MN	2	21	11.886	157	15.352

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/28/2011	8:48:21	MN	2	21	4.862	157	12.381
2/28/2011	8:49:48	MN	2	21	4.923	157	9.456
2/28/2011	8:51:36	MN	2	21	5.265	157	5.889
2/28/2011	8:52:15	CM	6	21	5.059	157	4.58
2/28/2011	8:52:36	CM	1	21	5.024	157	3.882
2/28/2011	8:53:00	CM	4	21	4.825	157	3.106
2/28/2011	8:53:21	CM	1	21	4.616	157	2.447
2/28/2011	8:53:48	MN	1	21	4.339	157	1.627
2/28/2011	8:55:21	MN	1	21	3.573	156	58.743
2/28/2011	8:55:39	CM	2	21	3.421	156	58.185
2/28/2011	8:56:03	CM	7	21	3.226	156	57.442
2/28/2011	8:57:27	CM	3	21	2.562	156	54.783
2/28/2011	8:58:48	MN	2	21	2.114	156	52.145
2/28/2011	8:59:36	MN	6	21	2.402	156	50.581
2/28/2011	9:01:42	CM	1	21	3.89	156	46.923
2/28/2011	9:02:18	CM	1	21	4.659	156	45.995
2/28/2011	9:02:51	MN	1	21	5.318	156	45.133
2/28/2011	9:03:27	CM	1	21	6.103	156	44.25
2/28/2011	9:04:24	MN	1	21	7.518	156	43.124
2/28/2011	9:08:00	MN	2	21	6.542	156	38.496
2/28/2011	9:10:06	MN	1	21	3.415	156	36.113
2/28/2011	9:10:24	MN	2	21	2.975	156	35.746
2/28/2011	9:12:09	CM	1	21	1.815	156	38.663
2/28/2011	9:13:39	CM	1	20	59.702	156	40.796
2/28/2011	9:18:54	MN	1	20	50.54	156	40.327
2/28/2011	9:19:51	MN	1	20	49.256	156	38.93
2/28/2011	9:22:36	MN	3	20	46.641	156	34.143
2/28/2011	9:24:48	MN	2	20	47.186	156	30.409
2/28/2011	9:28:33	MN	1	20	41.718	156	27.434
2/28/2011	9:28:45	MN	2	20	41.335	156	27.44
2/28/2011	9:30:45	MN	2	20	37.588	156	27.642
2/28/2011	9:32:04	MN	1	20	37.588	156	30.196
2/28/2011	9:32:31	MN	2	20	38.272	156	30.49

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/28/2011	9:32:52	MN	3	20	38.477	156	29.947
2/28/2011	9:36:10	MN	2	20	35.204	156	25.402
2/28/2011	9:47:27	UD	3	20	38.469	156	4.004
2/28/2011	9:54:06	MN	2	20	39.13	156	0.047
2/28/2011	10:10:39	MN	2	20	7.56	155	54.233
2/28/2011	10:14:09	MN	2	20	1.689	155	50.386
2/28/2011	10:14:12	MN	2	20	1.594	155	50.352
2/28/2011	10:15:54	MN	1	19	58.533	155	51.163
2/28/2011	10:19:15	MN	2	19	53.327	155	55.081
2/28/2011	10:19:18	MN	2	19	53.254	155	55.147
2/28/2011	10:21:33	MN	2	19	51.045	155	58.683
2/28/2011	10:25:48	SL	7	19	45.036	156	3.697
2/28/2011	12:20:03	SL	35	19	44.5	156	3.256
2/28/2011	13:36:01	MN	3	19	44.829	156	3.676
2/28/2011	13:39:10	MN	1	19	50.166	155	59.544
2/28/2011	13:39:13	MN	1	19	50.23	155	59.47
2/28/2011	13:44:04	MN	3	19	56.16	155	53.455
2/28/2011	13:46:22	MN	2	19	59.235	155	50.275
2/28/2011	13:51:16	MN	2	20	6.863	155	53.556
2/28/2011	13:53:13	MN	1	20	10.023	155	54.546
2/28/2011	13:53:16	MN	1	20	10.106	155	54.574
2/28/2011	13:56:16	MN	2	20	15.109	155	53.569
2/28/2011	13:57:58	MN	1	20	17.109	155	53.258
2/28/2011	14:00:31	MN	2	20	19.44	155	57.037
2/28/2011	14:19:16	MN	1	20	34.925	156	31.612
2/28/2011	14:19:58	MN	1	20	35.62	156	32.737
2/28/2011	14:20:40	MN	2	20	36.39	156	33.761
2/28/2011	14:21:13	MN	1	20	36.517	156	34.821
2/28/2011	14:21:49	SL	50	20	36.225	156	35.979
2/28/2011	14:30:40	MN	1	20	29.972	156	38.736
2/28/2011	14:31:07	MN	1	20	30.088	156	37.758
2/28/2011	14:33:13	MN	1	20	30.432	156	33.237
2/28/2011	14:36:43	MN	1	20	35.468	156	32.532

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
2/28/2011	14:57:43	MN	2	20	55.576	157	2.407
2/28/2011	14:58:16	MN	2	20	55.981	157	1.381
2/28/2011	14:58:31	MN	2	20	56.077	157	0.875
2/28/2011	15:03:49	MN	1	20	53.178	156	50.729
2/28/2011	15:05:55	MN	1	20	50.126	156	47.966
2/28/2011	15:09:58	MN	2	20	44.175	156	52.42
2/28/2011	15:10:22	MN	2	20	43.956	156	53.218
2/28/2011	15:11:34	MN	1	20	43.382	156	55.515
3/5/2011	7:42:24	CM	2	21	15.356	157	46.116
3/5/2011	7:43:03	CM	1	21	15.853	157	44.702
3/5/2011	7:56:06	MN	1	21	8.137	157	20.939
3/5/2011	8:01:27	CM	1	21	4.906	157	10.947
3/5/2011	8:02:21	MN	1	21	4.917	157	9.016
3/5/2011	8:02:48	MN	1	21	4.924	157	8.061
3/5/2011	8:04:15	CM	1	21	4.954	157	5.022
3/5/2011	8:07:33	MN	1	21	3.437	156	58.266
3/5/2011	8:09:03	MN	2	21	3.129	156	55.253
3/5/2011	8:12:27	MN	2	21	2.199	156	53.792
3/5/2011	8:13:54	CM	5	21	2.588	156	50.773
3/5/2011	8:14:24	CM	3	21	2.887	156	49.734
3/5/2011	8:18:03	MN	2	21	7.414	156	43.317
3/5/2011	8:20:15	MN	1	21	10.389	156	43.979
3/5/2011	8:21:24	MN	3	21	11.408	156	43.146
3/5/2011	8:25:48	MN	1	21	3.661	156	39.203
3/5/2011	8:29:33	MN	1	20	57.063	156	41.876
3/5/2011	8:32:57	MN	1	20	51.118	156	40.385
3/5/2011	8:34:06	MN	1	20	49.498	156	38.771
3/5/2011	8:34:21	MN	1	20	49.167	156	38.417
3/5/2011	8:34:51	MN	1	20	48.473	156	37.75
3/5/2011	8:35:18	GM	2	20	48.067	156	36.969
3/5/2011	8:38:24	MN	1	20	46.421	156	31.101
3/5/2011	8:39:03	MN	1	20	47.263	156	30.002
3/5/2011	8:41:30	MN	1	20	43.571	156	27.655

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
3/5/2011	8:43:21	MN	1	20	40.042	156	27.154
3/5/2011	8:51:51	MN	1	20	35.764	156	14.992
3/5/2011	9:02:00	MN	1	20	44.641	155	58.463
3/5/2011	9:18:24	MN	1	20	18.172	155	52.336
3/5/2011	9:27:33	TT	5	20	6.505	155	53.524
3/5/2011	9:28:12	MN	1	20	5.465	155	52.903
3/5/2011	9:33:27	MN	1	19	57.061	155	52.444
3/5/2011	9:35:39	MN	1	19	53.626	155	54.813
3/5/2011	9:40:15	MN	1	19	48.238	156	1.383
3/5/2011	12:01:00	MN	3	19	43.275	156	3.551
3/5/2011	12:32:12	MN	3	20	35.009	156	32.045
3/5/2011	12:32:42	MN	1	20	35.815	156	32.816
3/5/2011	12:45:39	MN	1	20	36.81	156	41.267
3/5/2011	12:52:39	MN	1	20	48.445	156	47.833
3/5/2011	12:52:51	MN	3	20	48.881	156	47.826
3/5/2011	12:53:39	MN	2	20	50.451	156	48.492
3/5/2011	12:54:54	MN	1	20	52.677	156	50.146
3/5/2011	12:55:18	MN	2	20	53.256	156	50.81
3/5/2011	12:55:51	MN	1	20	53.982	156	51.794
3/5/2011	13:14:00	SL	50	20	44.467	156	52.712
3/5/2011	13:18:33	MN	1	20	49.049	156	47.996
3/5/2011	13:18:36	MN	2	20	49.157	156	48.007
3/5/2011	13:18:39	MN	1	20	49.265	156	48.023
3/5/2011	13:20:33	MN	1	20	52.851	156	50.494
3/5/2011	13:20:48	MN	1	20	53.256	156	50.928
3/5/2011	13:21:36	MN	1	20	54.495	156	52.341
3/5/2011	13:21:39	MN	2	20	54.564	156	52.436
3/5/2011	13:22:06	MN	1	20	55.156	156	53.315
3/5/2011	13:22:54	MN	1	20	55.755	156	55.113
3/5/2011	13:23:27	MN	1	20	56.035	156	56.412
3/5/2011	13:24:57	MN	1	20	56.449	157	0.002
3/5/2011	13:29:00	MN	1	20	57.883	157	9.703
3/5/2011	13:34:51	MN	1	21	3.071	157	23.07

Date	Time	Species*	Composition (# Indivs)	Latitude (N)		Longitude (W)	
				(degrees)	(minutes)	(degrees)	(minutes)
3/5/2011	13:35:18	MN	1	21	3.372	157	24.142
3/5/2011	13:35:42	MN	1	21	3.605	157	25.089
3/5/2011	13:36:24	MN	1	21	3.98	157	26.805
3/5/2011	13:38:18	MN	3	21	5.039	157	31.433

*Species Code	Species (Latin name)
CM	green sea turtle (*Chelonia mydas*)
GM	short-finned pilot whale (*Globicephala macrorhynchus*)
MN	humpback whale (*Megaptera novaeangliae*)
PM	sperm whale (*Physeter macrocephalus*)
SL	spinner dolphin (*Stenella longirostris*)
TT	bottlenose dolphin (*Tursiops truncatus)*
UD	unidentified dolphin spp.
UW	unidentified whale spp.
UT	unidentified sea turtle spp.

APPENDIX B

Summaries of Behavior

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/16/11	7:40	1	No	2	MN	slow swim (sl sw)	270	
2/16/11	7:42	2	No	1	MN	sl sw	270	
2/16/11	13:17	3	No	2	MN	sl sw	N/A	
2/16/11	13:18	4	No	3	MN	sl sw	90	
2/16/11	13:20	5	No	1	MN	sl sw	110	
2/16/11	13:21	6	No	1	MN	sl sw	270	
2/16/11	13:23	7	No	1	MN	sl sw	90	
2/16/11	13:24	8	No	1	MN	sl sw	110	
2/16/11	13:25	9	No	1	MN	sl sw	200	
2/16/11	14:05	10	No	1	MN	sl sw	N/A	told to return to DDG; DDG confirmed same sighting
2/16/11	14:12	11	No	1	MN	sl sw	N/A	(could not video)
2/16/11	16:13	12	No	2	MN	sl sw	110	
2/16/11	16:14:10	13	No	3	MN	sl sw	300	
2/16/11	16:14:30	14	No	2	MN	sl sw	90	
2/17/11	7:44	1	No	2	MN	sl sw	90	
2/17/11	7:50	2	No	3	MN	milling; sl sw	N/A	
2/17/11	8:11	3	No	1	MN	sl sw	N/A	near DDG; directed away from sighting by Bravo
2/17/11	11:38	4	No	1	MN	breach	N/A	
2/17/11	11:42	5	No	2	MN	sl sw	270	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/17/11	11:45	6	No	1	MN	splash	270	
2/17/11	11:46	7	No	1	MN	blow	70	
2/17/11	11:49	8	No	1	MN	sl sw	90	
2/17/11	11:52	9	No	1	MN	sl sw	180	
2/17/11	13:39	10	No	1	MN	sl sw	360	
2/17/11	16:34	11	No	2	MN	sl sw	N/A	only puka
2/17/11	16:40	12	No	1	MN	sl sw	180	body at surface
2/18/11	9:58	1	No	4	MN	body	270	
2/18/11	9:59	2	No	1	MN	splash	90	
2/18/11	10:07	3	No	2	MN	body	270	
2/18/11	10:12	4	No	2	MN	milling	milling	
2/18/11	10:22	5	Yes	2	MN	sl sw	180	within 2–4 km DDG; likely same pod spotted by DDG per TJ
2/18/11	13:15	6	No	2	MN	splash	150	Focal follow pod; video
2/19/11	7:50	1	No	1	MN	blow only	N/A	Cascadia tagging support
2/19/11	7:53	2	No	1	MN	sl sw	90	
2/19/11	7:54	3	No	2	MN	sl sw	180	
2/19/11	7:55	4	No	1	MN	sl sw	90	
2/19/11	7:56	5	No	1	MN	underwater (UW)	300	
2/19/11	7:57	6	No	2	MN	sl sw	270	
2/19/11	7:58	7	No	4	UD	sl sw	270	
2/19/11	8:07	8	No	4	GM	sl sw	270	same group that Cascadia tagged yesterday
2/19/11	9:50	9	No	1	MN	sl sw	270	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/19/11	10:46	10	No	4 (1)	MN	splash; tail-lob, then milling	270	
2/19/11	10:56	11	No	4	MN	milling	N/A	Nakana via window
2/19/11	10:56		No	10 (1)	GM	milling	N/A	GM group with 4 humpbacks
2/19/11	13:25	12	No	3	MN	sl sw	90	CC&E
2/19/11	13:39	13	No	18	GM	milling	N/A	
2/19/11	13:42	14	No	3	UD	fast swim	270	
2/19/11	14:20	15	No	35	SL	fast swim	70	
2/19/11	15:28	16	No	4	GM	milling	90	
2/19/11	15:35	17	No	3	UD	milling	N/A	likely pilot whale
2/24/11	8:46	1	No	2	MN	sl sw	90	
2/24/11	8:47	2	No	2	MN	sl sw	90	
2/24/11	8:51	3	No	2	MN	sl sw	45	
2/24/11	8:53	4	No	2	MN	sl sw	90	
2/24/11	8:53:30	5	No	3	MN	sl sw	290	
2/24/11	9:02	6	No	3	MN	sl sw	90	
2/24/11	9:05	7	No	1	MN	sl sw	270	
2/24/11	9:08	8	No	1	MN	sl sw	180	
2/24/11	9:15	9	No	2	MN	milling; surface active, pec slap	N/A	
2/24/11	9:19	10	No	1	MN	milling	N/A	inside Lehua Rock
2/24/11	9:26	11	No	3	MN	sl sw	300	
2/24/11	9:29	12	No	1	MN	milling; breach	N/A	
2/24/11	9:30	13	No	2	MN	sl sw	N/A	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/24/11	9:30:30	14	No	1	MN	sl sw	360	
2/24/11	9:32	15	No	2	MN	sl sw	60	
2/24/11	9:32:30	16	No	1	MN	sl sw	360	
2/24/11	9:33	17	No	1	MN	sl sw	130	
2/24/11	9:35	18	No	1	MN	UW	350	
2/24/11	9:36	19	No	2 (1)	MN	UW	360	
2/24/11	9:36:30	20	No	110	SL	milling; sl travel; spinning	350	
2/24/11	9:45	21	No	1	MN	blow	180	
2/24/11	9:45:30	22	No	1	MN	breach	N/A	
2/24/11	9:47	23	No	2	MN	sl sw	10	
2/24/11	9:50	24	No	3	MN	milling; surface active	N/A	
2/24/11	9:53	25	No	1	MN	sl sw	40	
2/24/11	9:58	26	No	1	MN	breach	N/A	
2/24/11	9:59	27	No	1	MN	tail lob	N/A	
2/24/11	10:00	28	No	1	MN	sl sw	90	
2/24/11	10:04	29	No	1	MN	sl sw	360	
2/24/11	10:16	30	No	1	MN	breach	10	
2/24/11	10:29	31	No	1	CM	sl sw	N/A	
2/24/11	10:29:10	32	No	1	CM	sl sw	N/A	
2/24/11	10:34	33	No	5	CM	sl sw	N/A	
2/24/11	10:34:30	34	No	12	SL	milling; rest	N/A	tight aggregation inside small bay
2/24/11	10:55	35	No	1	CM	sl sw	N/A	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/24/11	10:58	36	No	2	MN	milling; sl sw	N/A	
2/24/11	11:00	37	No	1	CM	sl sw	N/A	
2/24/11	11:06	38	No	4	MN	sl sw	190	
2/24/11	11:20	39	No	4	CM	sl sw	N/A	
2/24/11	12:26	40	No	3	UW	dove	N/A	
2/24/11	12:31	41	No	3	PM	breach; blows synchronous	N/A	photos
2/26/11	8:35:31	1	No	4	MN	surface active	N/A	
2/26/11	8:39:29	2	No	2	MN	sl sw	90	
2/26/11	8:45:30	3	No	20	UD	uw swim; tightly coalesced	N/A	
2/26/11	8:45:31	4	No	2	MN	sl sw	N/A	
2/26/11	8:54:08	5	No	2 (1)	MN	sl sw	180	
2/26/11	8:54:35	6	No	2	MN	sl sw	350	
2/26/11	8:55:07	7	No	2	MN	sl sw	350	
2/26/11	8:56:04	8	No	1	CM	sl sw	N/A	
2/26/11	8:56:19	9	No	2	CM	sl sw	N/A	
2/26/11	8:56:35	10	No	3	CM	sl sw	N/A	
2/26/11	8:57:17	11	No	1	CM	sl sw	N/A	
2/26/11	8:57:20	12	No	2	CM	sl sw	N/A	
2/26/11	8:57:40	13	No	2	CM	sl sw	N/A	
2/26/11	8:57:53	14	No	3	CM	sl sw	N/A	
2/26/11	8:58:56	15	No	1	CM	sl sw	N/A	
2/26/11	8:59:18	16	No	1	CM	sl sw	N/A	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/26/11	8:59:55	17	No	2	MN	sl sw	N/A	
2/26/11	9:02:03	18	No	2	CM	sl sw	N/A	
2/26/11	9:03:44	19	No	1	CM	sl sw	N/A	
2/26/11	9:07:12	20	No	3	UD	no resight	N/A	circling limited due to Na Pali
2/26/11	9:10:02	21	No	2 (1)	MN	sl sw	N/A	
2/26/11	9:12:10	22	No	7	UD	sl sw	N/A	
2/26/11	9:12:40	23	No	1	CM	sl sw	N/A	
2/26/11	9:13:15	24	No	1	CM	sl sw	N/A	
2/26/11	9:13:49	25	No	1	CM	sl sw	N/A	
2/26/11	9:17:42	26	No	1	MN	milling; surface active	N/A	
2/26/11	9:18:14	27	No	1	MN	sl sw	200	
2/26/11	9:18:28	28	No	1	MN	sl sw	270	
2/26/11	9:25:41	29	No	2	MN	sl sw	350	
2/26/11	9:26:11	30	No	175	SL	sl sw	360	clumps fairly wide apart
2/26/11	9:26:12	31	No	2	MN	sl sw	350	
2/26/11	9:32:36	32	No	1	CM	sl sw	100	
2/26/11	9:34:58	33	No	40 (1)	SL	sl sw	N/A	uw tightly aggregated
2/26/11	9:39:05	34	No	50	SL	milling	N/A	
2/26/11	9:39:44	35	No	2	MN	milling	N/A	
2/26/11	9:40:48	36	No	2 (1)	MN	sl sw	180	
2/26/11	9:41:56	37	No	2	MN	stationary	N/A	sitting on bottom
2/26/11	9:43:28	38	No	2 (1)	MN	sl sw	350	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/26/11	9:43:58	39	No	2	MN	sitting on bottom	N/A	
2/26/11	9:44:23	40	No	2	MN	sitting on bottom	N/A	
2/26/11	9:46:07	41	No	1 (1)	MN	milling	N/A	lone calf
2/26/11	9:49:25	42	No	2	MN	sl sw	270	
2/26/11	9:50:20	43	No	2	MN	sl sw	270	
2/26/11	9:52:14	44	No	1 (1)	MN	stationary	N/A	lone calf
2/26/11	9:53:25	45	No	1	MN	sl sw	350	
2/26/11	9:54:46	46	No	1	MN	sl sw	350	
2/26/11	9:55:20	47	No	3	MN	UW swim	350	
2/26/11	9:56:56	48	No	2	MN	sl sw	90	
2/26/11	9:57:28	49	No	1	MN	sl sw	270	
2/26/11	10:02:45	50	No	11	UD	sl sw	180	spread out
2/26/11	10:11:52	51	No	2	MN	sl sw	360	
2/26/11	10:12:48	52	No	2	MN	sl sw	360	
2/26/11	10:17:43	53	No	85	SL	milling; dispersed spinning	N/A	
2/26/11	10:23:39	54	No	1	MN	sl sw	270	
2/26/11	10:34:02	55	No	1	MN	sl sw	90	sl sw off airport
2/26/11	12:07:49	56	No	1	MN	sl sw	90	
2/26/11	12:09:07	57	No	1	MN	sl sw	270	
2/26/11	12:15:23	58	No	6 (1)	PM	sl sw	90	sperm whales!
2/26/11	12:24:22	59	No	2 (1)	PM	surface swim	90	
2/26/11	12:26:05	60	No	3	PM	surface swim	90	whale poop!

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/28/11	8:05:06	1	No	2	CM	sl sw	N/A	
2/28/11	8:07:40	2	No	3	MN	sl sw	270	
2/28/11	8:09:26	3	No	2	CM	sl sw	N/A	
2/28/11	8:15:03	4	No	2	MN	sl sw	270	
2/28/11	8:15:59	5	No	1	CM	sl sw	90	
2/28/11	8:16:20	6	No	1	CM	sl sw	90	
2/28/11	8:16:58	7	No	3	CM	sl sw	N/A	
2/28/11	8:17:25	8	No	3	CM	sl sw	N/A	
2/28/11	8:18:12	9	No	3	CM	sl sw	N/A	
2/28/11	8:22:10	10	No	1	CM	sl sw	N/A	
2/28/11	8:23:13	11	No	1	CM	sl sw	N/A	
2/28/11	8:28:48	12	No	2	MN	sl sw	300	
2/28/11	8:35:15	13	No	2	MN	sl sw	360	
2/28/11	8:36:29	14	No	1	MN	sl sw	360	
2/28/11	8:39:31	15	No	2	MN	1 breached	270	
2/28/11	8:48:20	16	No	2	MN	UW	270	
2/28/11	8:49:47	17	No	2	MN	sl sw	270	
2/28/11	8:51:37	18	No	2	MN	blow	270	
2/28/11	8:52:15	19	No	6	CM	sl sw	N/A	
2/28/11	8:52:35	20	No	1	CM	sl sw	N/A	
2/28/11	8:52:59	21	No	4	CM	sl sw	N/A	
2/28/11	8:53:20	22	No	1	CM	sl sw	N/A	
2/28/11	8:53:48	23	No	1	MN	sl sw	300	body visible uw

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/28/11	8:55:22	24	No	1	MN	slow dive	N/A	
2/28/11	8:55:40	25	No	2	CM	sl sw	N/A	
2/28/11	8:56:03	26	No	7	CM	sl sw	N/A	
2/28/11	8:57:28	27	No	3	CM	sl sw	N/A	
2/28/11	8:58:48	28	No	2	MN	sl sw	90	
2/28/11	8:59:36	29	No	6	MN	sl sw	90	
2/28/11	9:01:42	30	No	1	CM	sl sw	N/A	
2/28/11	9:02:18	31	No	1	CM	sl sw	N/A	
2/28/11	9:02:50	32	No	1	MN	dove	N/A	Puka
2/28/11	9:03:28	33	No	1	CM	sl sw	N/A	
2/28/11	9:04:25	34	No	1	MN	sl sw	310	
2/28/11	9:08:00	35	No	2	MN	sl sw	200	
2/28/11	9:10:06	36	No	1	MN	sl sw	N/A	
2/28/11	9:10:25	37	No	2	MN	sl sw	270	
2/28/11	9:12:08	38	No	1	CM	sl sw	N/A	
2/28/11	9:13:40	39	No	1	CM	sl sw	N/A	
2/28/11	9:18:53	40	No	1	MN	sl sw	110	
2/28/11	9:19:52	41	No	1	MN	UW	90	
2/28/11	9:22:37	42	No	3	MN	sl sw	200	
2/28/11	9:24:48	43	No	2	MN	sl sw	N/A	
2/28/11	9:28:33	44	No	1	MN	blow	180	
2/28/11	9:28:44	45	No	2	MN	sl sw	180	
2/28/11	9:30:45	46	No	2	MN	sl sw	180	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/28/11	9:31:29	47	No	2	MN	blow	350	
2/28/11	9:32:04	48	No	1	MN	breach	N/A	
2/28/11	9:32:31	49	No	2	MN	sl sw	240	
2/28/11	9:32:52	50	No	3	MN	sl sw	45	
2/28/11	9:36:10	51	No	2	MN	blow; then UW	90	
2/28/11	9:47:25	52	No	3	UD	UW swim	90	
2/28/11	9:54:05	53	No	2	MN	UW swim	90	
2/28/11	10:10:40	54	No	2	MN	blow	270	
2/28/11	10:14:09	55	No	2	MN	blow	300	line abreast in groups of two
2/28/11	10:14:10	56	No	2	MN		300	
2/28/11	10:15:55	57	No	1	MN	sl sw	110	
2/28/11	10:19:15	58	No	2	MN	pec slap; side swim	350	
2/28/11	10:19:16	59	No	2	MN	sl sw	350	
2/28/11	10:21:32	60	No	2	MN	UW swim	200	
2/28/11	10:25:48	61	No	7	SL	spinning; milling	N/A	boat present
2/28/11	12:20:03	62	No	35	SL	sl sw	45	large group sighted during final approach
2/28/11	13:36:00	63	No	3 (1)	MN	sl sw	180	
2/28/11	13:39:11	64	No	1	MN	sl sw	350	
2/28/11	13:39:13	65	No	1	MN	sl sw	350	
2/28/11	13:44:05	66	No	3 (1)	MN	blow; UW swim	45	
2/28/11	13:46:22	67	No	2 (1)	MN	sl sw	45	
2/28/11	13:51:17	68	No	2	MN	sl sw	350	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/28/11	13:53:13	69	No	1	MN	breach	N/A	
2/28/11	13:53:14	70	No	1	MN	sl sw	350	
2/28/11	13:56:15	71	No	2	MN	sl sw	350	
2/28/11	13:57:58	72	No	1	MN	sl sw	130	
2/28/11	14:00:30	73	No	2	MN	sl sw	130	
2/28/11	14:19:17	74	No	1	MN	breach	N/A	
2/28/11	14:19:58	75	No	1	MN	blow	N/A	
2/28/11	14:20:40	76	No	2	MN	sl sw	270	
2/28/11	14:21:13	77	No	1	MN	stationary UW	N/A	
2/28/11	14:21:48	78	No	50	SL	milling; mostly UW	N/A	
2/28/11	14:30:40	79	No	1	MN	sl sw	270	
2/28/11	14:31:08	80	No	1	MN	sl sw	90	
2/28/11	14:33:12	81	No	1	MN	sl sw	90	body
2/28/11	14:36:43	82	No	1	MN	sl sw	330	
2/28/11	14:57:43	83	No	2	MN	UW swim; splash	40	
2/28/11	14:58:16	84	No	2	MN	sl sw	120	
2/28/11	14:58:30	85	No	2	MN	sl sw	180	
2/28/11	15:03:48	86	No	1	MN	UW	270	
2/28/11	15:04:49	87	No	2	MN	blow	30	
2/28/11	15:05:55	88	No	1	MN	sl sw	90	
2/28/11	15:09:58	89	No	2	MN	sl sw	270	
2/28/11	15:10:23	90	No	2 (1)	MN	breach simultaneous	N/A	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/28/11	15:11:34	91	No	1	MN	UW; slow surface	90	
3/5/11	7:42:24	1	No	2	CM	sl sw	N/A	
3/5/11	7:43:02	2	No	1	CM	sl sw	N/A	
3/5/11	7:56:07	3	No	1	MN	UW swim	90	
3/5/11	8:01:26	4	No	1	CM	sl sw	N/A	
3/5/11	8:02:22	5	No	1	MN	UW swim	N/A	
3/5/11	8:02:49	6	No	1	MN	blow; sl sw	270	
3/5/11	8:04:15	7	No	1	CM	sl sw	N/A	
3/5/11	8:07:33	8	No	1	MN	side swim; then dive	180	
3/5/11	8:09:04	9	No	2 (1)	MN	sl sw; shallow dive	110	
3/5/11	8:12:28	10	No	2	MN	breach	180	
3/5/11	8:13:54	11	No	5	CM	sl sw	N/A	
3/5/11	8:14:23	12	No	3	CM	sl sw	N/A	
3/5/11	8:18:04	13	No	2	MN	both circular swim UW	N/A	
3/5/11	8:20:16	14	No	1	MN	blow	90	
3/5/11	8:21:25	15	No	3	MN	sl sw	90	
3/5/11	8:25:49	16	No	1	MN	sl sw	90	
3/5/11	8:29:32	17	No	1	MN	blow; sl sw	180	
3/5/11	8:32:58	18	No	1	MN	diving	360	
3/5/11	8:34:07	19	No	1	MN	dove	N/A	
3/5/11	8:34:20	20	No	1	MN	dove	N/A	
3/5/11	8:34:50	21	No	1	MN	sl sw	270	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
3/5/11	8:35:19	22	No	2	GM	sl sw	270	
3/5/11	8:38:25	23	No	1	MN	sl sw	120	
3/5/11	8:39:04	24	No	1	MN	breach	N/A	
3/5/11	8:41:31	25	No	1	MN	blow	180	
3/5/11	8:43:21	26	No	1	MN	stationary	N/A	
3/5/11	8:51:52	27	No	1	MN	blow	N/A	
3/5/11	9:02:00	28	No	1	MN	sl sw; UW	90	
3/5/11	9:18:24	29	No	1	MN	sl sw; surface	180	
3/5/11	9:27:32	30	No	5	TT	sl sw	180	
3/5/11	9:28:11	31	No	1	MN	sl sw	180	
3/5/11	9:33:28	32	No	1	MN	sl sw	180	
3/5/11	9:35:39	33	No	1	MN	sl sw	180	
3/5/11	9:40:16	34	No	1	MN	sl sw	180	
3/5/11	12:01	35	No	3	MN	breach	350	
3/5/11	12:31:59	36	No	2	MN	sl sw	90	
3/5/11	12:32:11	37	No	3	MN	UW swim	90	
3/5/11	12:32:41	38	No	1	MN	pec-slap	270	
3/5/11	12:45:38	39	No	1	MN	sl sw	350	
3/5/11	12:52:40	40	No	1	MN	UW stationary	180	
3/5/11	12:52:50	41	No	3	MN	sl sw	360	
3/5/11	12:53:40	42	No	2	MN	blow; sl sw	90	
3/5/11	12:54:55	43	No	1	MN	UW swim	270	
3/5/11	12:55:19	44	No	2 (1)	MN	sl sw	90	

Date	Time	Grp#	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
3/5/11	12:55:52	45	No	1	MN	breach	90	
3/5/11	13:14:00	46	No	50	SL	milling	N/A	tightly coalesced group in Manele Bay
3/5/11	13:18:33	47	No	1	MN	sl sw	45	
3/5/11	13:18:36	48	No	2	MN	fast swim	90	
3/5/11	13:18:39	49	No	1	MN	UW swim	180	
3/5/11	13:20:32	50	No	1	MN	dove	N/A	
3/5/11	13:20:49	51	No	1	MN	sl sw	20	
3/5/11	13:21:35	52	No	1	MN	sl sw	45	
3/5/11	13:21:40	53	No	2	MN	sl sw	90	
3/5/11	13:22:05	54	No	1	MN	UW swim	280	
3/5/11	13:22:55	55	No	1	MN	sl sw	110	
3/5/11	13:23:28	56	No	1	MN	blow	100	
3/5/11	13:24:57	57	No	1	MN	blow	90	
3/5/11	13:29:01	58	No	1	MN	splash	90	
3/5/11	13:34:52	59	No	1	MN	blow only	N/A	
3/5/11	13:35:18	60	No	1	MN	splash	N/A	
3/5/11	13:35:43	61	No	1	MN	sl sw	90	
3/5/11	13:36:23	62	No	1	MN	sl sw	180	
3/5/11	13:38:19	63	No	3 (1)	MN	sl sw	90	

APPENDIX C

Detail of Videotaped Focal Follow

Date	Clock Begin	Elapsed Begin	Description	Lat/Lon (degrees)	Pod on Video (Y/N)
Feb. 18	13:19	0:02	Session starts—two humpbacks sighted within 2–4 km of DDG; pod is underwater at start; good sighting conditions (Bf 3); heading 150		N
	13:21	2:06	Pod at surface; visible blow, large splash, peduncle slap by closer whale, then blow; closer animal fluke-up dive; puka visible		Y
	13:21	2:35	Further animal dove; both animals now underwater		N
	13:23	4:38	Both animals up (per audio); backs visible at elapsed time (ET) 4:41; then submerged; blow at ET 5:04, both whales visible, blow at ET 5:30; both submerged at ET 5:34		Y
	13:24	5:34	Both animals submerged, no longer visible		N
	13:26	6:46	Pukas visible (might have missed surfacing)		N
	13:30	11:03	Pilot confirms surfacing (forward of plane); not visible in frame; going in and out of clouds		N
	13:36	17:34	Observer sights pod at surface; blows visible in frame briefly; (aircraft now at 1,400 feet to avoid clouds)		Y
	13:37	17:50	Both animals submerged; no longer visible		N
	13:42	23:18	Conditions changed to Bf 4; still good visibility		N
	13:43	23:46	Pilot sights blow behind left engine; pilot reports both visible (ET 24:13); still swimming line abreast approx. 2 whale lengths apart, heading 150; pilot reports whales no longer visible (ET 25:03)		N
	13:47	28:02	Chafee visible in frame still within 2–4 km		N
	13:50	30:48	Pilot sees blow; not yet visible in frame; still up at ET 31:30;		N
	13:51	32:08	Breaking off episode; animals not visible		N

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APPENDIX F. Preliminary Results from a Deep-water Ecological Acoustic Recorder (EAR) Deployed off NW Niʻi hau during RIMPAC-2010

PRELIMINARY RESULTS FROM A DEEP-WATER ECOLOGICAL ACOUSTIC RECORDER (EAR) DEPLOYED OFF NW NI'IHAU DURING RIMPAC-2010

Prepared by

HDR

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JUNE 2011

PRELIMINARY RESULTS FROM A DEEP-WATER ECOLOGICAL ACOUSTIC RECORDER (EAR) DEPLOYED OFF NW NI'IHAU DURING RIMPAC-2010

HDR | EOC, INC; WHITLOW W. L. AU, HAWAI'I INSTITUTE OF MARINE BIOLOGY, UNIVERSITY OF HAWAI'I AT MANOA

An Ecological Acoustic Recorder (EAR) was deployed on July 17, 2010 at a depth of 800 m off the northwest coast of the island of Ni'ihau (21° 59.613" N, 160° 12.167" W). A map of the deployment site is shown in **Figure 1**. The sampling rate for data acquisition was 80 kHz and the duty cycle for turn-on and sleep was 30 sec of sampling every 5 minutes. The deep EAR was recovered on December 21, 2010 (although it had ceased recording on October 22) with a full disk containing 28,329 files of data.

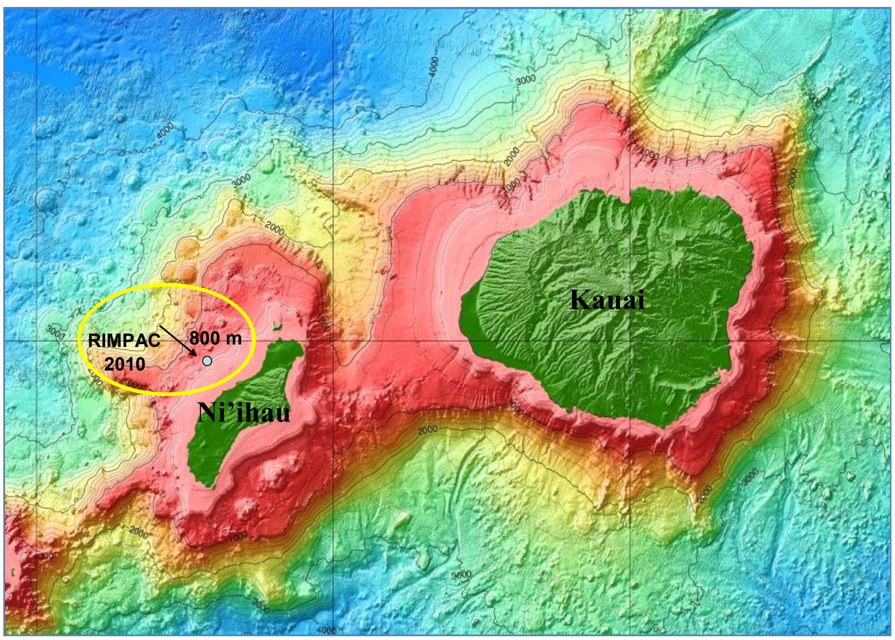

Figure 1. Approximate location of the deep EAR deployed in waters NW of Ni'ihau during RIMPAC-2010.

Three signal detectors were used to determine the presence of beaked whales: 1) the energy ratio mapping algorithm (ERMA) developed by Holger Klinck (Klinck and Mellinger, 2011), 2) the support vector machine algorithms incorporated within the M3R (Marine Mammal Monitoring on Navy Range) developed by Susan Jarvis (Jarvis et al., 2008) and 3) a custom MATLAB algorithm developed for this project. Both ERMA and the M3R algorithms operate automatically and are handy for a first look at the data. The beaked whale detections obtained by ERMA and the M3R were matched against each other, and if both detectors indicated a beaked whale present in a particular file, this constituted a positive identification. If only one detector indicated the presence of a beaked whale, then the file was examined by a custom MATLAB algorithm which examined the waveform, spectrum and the time-frequency distribution obtained via a Wigner-

Ville distribution analysis of signals in the file. Approximately 40 percent of beaked whale detections were matched by the ERMA and M3R detectors, meaning that 60 percent (approximately 1,200 files) of possible beaked detections had to be examined visually with the semi-automatic custom MATLAB program.

The daily detections of beaked whales, and the number of detections at different hours of the day, are shown in **Figure 2**. The panel on the left indicates that beaked whales are detected almost every day, with the number of detections dependent on specific days. There were 9 out of 98 days in which no beaked whales were detected. Most (approximately 87 percent) of the detections occurred at night, as can be seen in the shaded portion of the right panel in **Figure 2**. The reason for detections occurring mainly at night is likely dependent on the behavior of the prey field.

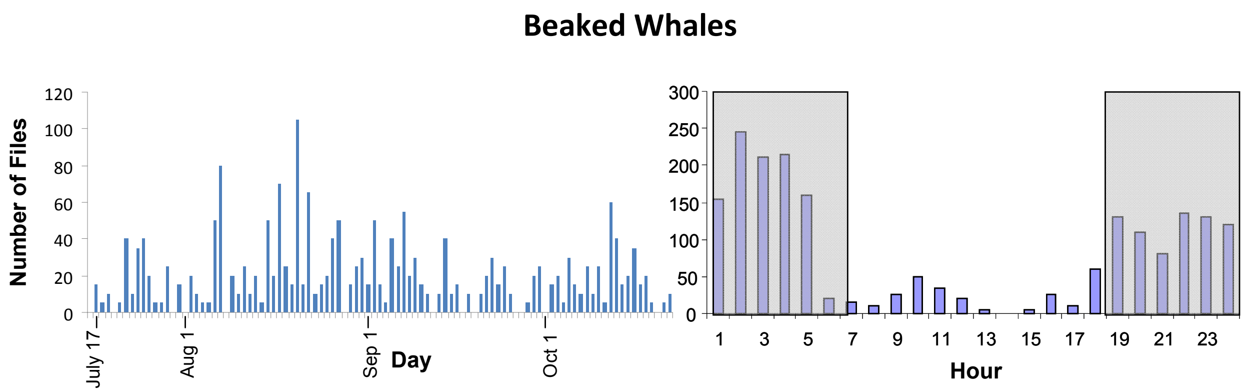

Figure 2. Beaked whale detections from the deep EAR deployed in waters NW Ni'ihau during Rimpac-2010.

The M3R system is also capable of detecting other groups of odontocetes based on the characteristics of their biosonar signals. These include pilot whales (*Globicephala spp.*), Risso's dolphins (*Grampas griseus*), sperm whales (*Physeter macrocephalus*) and dolphins in the *Stenella* genus. The relative numbers of detections of these groups, along with those of beaked whales are shown in **Figure 3**. Pilot whales had the highest number of detections, while beaked whales had the least number of detections. It is interesting that Risso's dolphins were the 2nd most detected odontocetes, since they are not consistently sighted in Hawaiian waters.

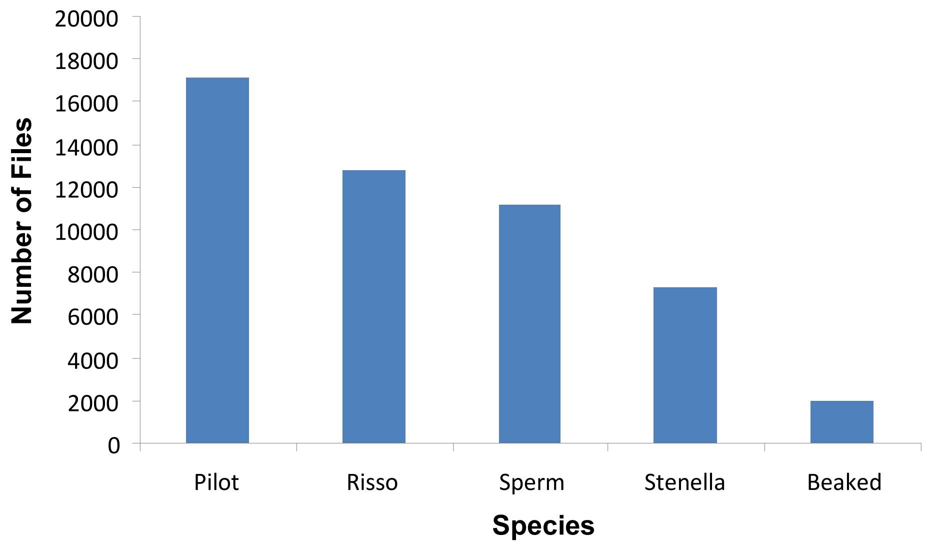

Figure 3. Relative number of files containing the different species of odontocetes detected by the M3R system.

REFERENCES:

Klinck, H., and Mellinger, D.K. (**2011**). "The energy ratio mapping algorithm: a tool to improve the energy-based detection of odontocete echolocation clicks." J. Acoust. Soc. Am. **129**, 1807-1812.

Jarvis, S., DiMarzio, N., Morrissey, R., and Moretti, D. (**2008**). "A novel multi-class support bector machine classifier for automated classification of beaked whales and other small odontocetes," Canadian Acoustics, **36**, 34-40.

APPENDIX G. Cruise Report, Marine Species Monitoring Effectiveness Study, Koa Kai, November 2010, Hawaii Range Complex

February 2011

Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study Koa Kai, November 2010, Hawaii Range Complex

Prepared for:
Commander, U.S. Pacific Fleet

Prepared by:

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List of Acronyms and Abbreviations

DMMO	data marine mammal observer
ft	foot (feet)
GPS	global positioning system
HRC	Hawaii Range Complex
km	kilometer(s)
LMMO	liaison marine mammal observer
LO	Navy Lookout
m	meter(s)
mm	millimeter
MFAS	mid-frequency active sonar
MMO	marine mammal observer
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
PMAP	Protective Measures Assessment Protocol
SMMO	survey marine mammal observer
VHF	very high frequency
yd(s)	yard(s)

INTRODUCTION

In order to train with mid-frequency active sonar (MFAS), the United States (U.S.) Navy has obtained a Letter of Authorization (permit) from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and a Biological Opinion under the Endangered Species Act. The Hawaii Range Complex (HRC) Monitoring Plan, implemented in January 2009, was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting will provide science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy MFAS. The objectives of the monitoring plan are to address the following questions:

1. Are marine mammals and sea turtles exposed to MFAS at regulatory thresholds of harm or harassment? If so, at what levels and how frequently are they exposed?
2. If marine mammals and sea turtles are exposed to MFAS in the HRC, do they redistribute geographically in the HRC as a result of repeated exposure? If so, how long does the redistribution last?
3. If marine mammals and sea turtles are exposed to MFAS, what are their behavioral responses? Are they different at various levels?
4. What are the behavioral responses of marine mammals and sea turtles that are exposed to various levels and distances from explosives?
5. Are the Navy's suite of mitigation measures for MFAS and explosives (e.g., Protective Measures Assessment Protocol [PMAP], measures agreed to by the Navy through permitting and consultation) effective at avoiding harm or harassment of marine mammals and sea turtles?

In order to address these questions, data would be collected through various means, including contracted vessel and aerial surveys, tagging, passive acoustics, and placing marine mammal observers (MMOs) aboard Navy warships.

In a concerted effort to address the fifth question above, a study was initiated to determine the effectiveness of the Navy lookout team, including lookouts in the pilot house, on the bridge wings, and/or the forward lookout on the flying bridge. Trained biologists were utilized for the study to collect data that would characterize the likelihood of detecting marine species in the field from a U.S. Navy cruiser (CG). The University of St. Andrews, Scotland, under contract to the U.S. Navy, developed an initial protocol for use during this study. Necessary changes to the protocol were identified and made during three prior implementations. Data collected are intended to be combined with future monitoring efforts in order to determine the effectiveness of Navy lookout teams as a whole, rather than specific to each vessel.

As part of this data collection effort, four U.S. Navy civilian MMOs (Ms. Amy Farak, Ms. Morgan Richie, Ms. Julie Rivers, and Dr. Robert Uyeyama) participated in an event on the Hawaii Range Complex on 12-16 November, 2010. These MMOs were stationed aboard a US Navy cruiser, hereafter referred to as CG-A. The goals of the monitoring and this study were:

1. Collect data to assess the effectiveness of the Navy lookout team.
2. Obtain data to characterize the possible exposure of marine species to MFAS.

METHODS

MMO surveys were conducted on a not-to-interfere basis, which means that the MMOs would not replace required Navy lookouts, would not dictate operational requirements/maneuvers, and would remove themselves from the bridge wing if necessary for CG-A to accomplish its mission objectives. The exceptions would be if a marine mammal was sighted by the MMO within the shut-down zone during MFAS (200 yards [yds], 183 meters [m]) and was not sighted by the Navy lookout team, or if the vessel was in danger of striking the marine species. In these cases, the MMO would report the sighting to the Navy lookout team for appropriate reporting and action.

The initial protocol for data collection was provided by the University of St. Andrews; this protocol was modified by the MMOs on four prior surveys. Additional changes were made as necessary during this event. The MMO survey on CG-A was conducted on the bridge wings (elevated 60 feet [ft; 20 m] above the waterline), with one MMO on each wing (called survey MMOs, or SMMOs). One MMO acted as a liaison to the lookout team (called liaison MMO or LMMO), and was provided a headset to listen to the Navy lookout team conversation. The fourth MMO was primarily responsible for recording data (data MMO or DMMO) reported by the two SMMOs and the LMMO. A rotation schedule was used, such that an MMO would be on effort for one hour on port, one hour as the LMMO, one hour as an SMMO on starboard, and one hour as DMMO. While on effort, MMOs used naked eye and 7 X 50 magnification binoculars to scan the area from dead ahead to just aft of the beam.

If an animal was visually detected by the SMMOs, information would be collected on twenty-three sighting, environmental, and operational parameters. Sightings obtained first by the SMMOs (between 270° and 90°relative to the ship) before the Navy lookout were considered to be “trials.” If applicable, photographs would be taken using a Canon EOS 20D digital camera with a 100 – 300 millimeter [mm] zoom lens. No photographs would be taken until the Navy lookout had also made the sighting so as not to inappropriately call attention to the sighting. The track of the CG-A was not altered as result of the sightings, unless to avoid a collision. Therefore, the species identification level represents the best ability to recognize species specific characteristics at a distance from the ship, without approaching the animals for study.

The LMMO reported sightings made by the Navy lookout team, including the bridge team and aft watchstander. After a sighting by the Navy lookout or bridge team, the LMMO would also query the personnel to clarify information on the sighting such as animals seen, bearing, distance, and time. All four MMOs were equipped with headset two-way radios in order to maintain communications without leaving post, as well as communicating sighting and effort data without cueing the Navy lookouts to sightings. The DMMO was responsible for recording all data and making initial determination as to whether sightings were considered a duplicate.

The DMMO recorded effort-related events (e.g., begin effort, end effort, observer rotation, and weather changes) as per the protocol. At the time of events and sightings, a waypoint was immediately taken by the DMMO such that the accurate time and location would be recorded, with associated information to be appended. Effort and environmental information was collected when the MMOs began effort, at each rotation, as weather changes occurred, and when the MMOs went off effort. At the conclusion of the cruise, photographs were reviewed to assist with species identification.

RESULTS

Effort and environmental information was collected when the MMOs began effort, at each rotation, as weather changes occurred, and when the MMOs went off effort. The MMO team spent 35 hours and 7 minutes searching for marine species during the exercise (1). Three people were vigilant during virtually all of the on effort hours; therefore this study comprised a total of 105 hours and 21 minutes of marine mammal shipboard monitoring. The DMMO was often observing when there were no data to record but this effort was not recorded and therefore not included, and the LMMO was vigilant through the majority of the rotation. A majority (56%) of time on effort was during Beaufort Sea States 4 and 5 (Figure).

Table 1. Effort Hours and Environmental Conditions

Date	Team Hours On-Effort	Time	Beaufort Sea State (range)	% Cloud Cover (range, conditions)	Visibility
12 Nov	5 hr 26 min	1201-1727	3-5	60 – 85	Good
13 Nov	9 hr 37 min	0643-1144, 1254-1730	3 – 6	5 – 75	Good
14 Nov	8 hr 54 min	0724-1130, 1225-1631, 1708-1750	2 – 5	5 – 75	Good – Excellent
15 Nov	9 hr 19 min	0633-1128, 1237-1532, 1601-1730	4 – 7	10 – 100	Moderate – Good
16 Nov	1 hr 51 min	0633-0824	1 – 3	10	Good – Excellent
Total	**35 hr 07 min** (105 hr 21 min for three MMOs)		**1 – 7**	**0 – 100**	**Moderate – Excellent**

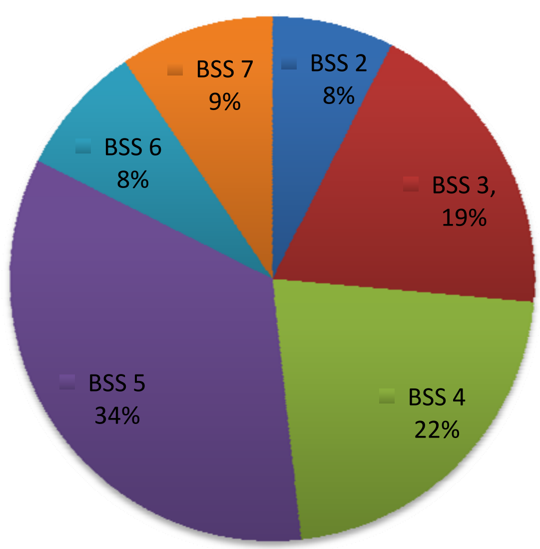

Figure 1. Percentage of Effort at each Beaufort Sea State (BSS)

In total, three sightings of marine mammals and five sea turtles were recorded during the five days of observation (2). Two of the marine mammal sightings and four of the sea turtle sightings were made independently by the MMOs, that is, not seen by the Navy lookout team (Table 3). One pod of dolphins was observed by the bridge and reported to the SMMOs. Additionally, the other pod of dolphins was observed by one of the officers standing on the bridge wing, but was not reported to the lookout team or recorded by the bridge, and therefore was not considered to be seen by the lookout team. The Navy lookout team recorded one independent sighting of a sea turtle.

Table 2. Marine Mammal and Sea Turtle Sightings

Date	Time	Latitude	Longitude	Species	Behavior/Notes
11/12/10	123645	21.30447	-157.959	Green turtle	At surface then dove at abeam.
11/13/10	072334	21.58836	-157.321	Unidentified Balaenopterid	Tall blow, probably humpback.
11/13/10	141735	21.077	-157.909	Unidentified sea turtle	Swimming at surface.
11/16/10	070331	21.10289	-157.94	Spinner dolphin	Bowriding.
11/16/10	075813	21.26614	-157.94	Spotted dolphin	Feeding in association with birds.
11/16/10	080858	21.30111	-157.624	Green turtle	Swimming at surface.
11/16/10	081401	21.31828	-157.967	Green turtle	Swimming at surface.
11/16/10	081536	21.32369	-157.968	Green turtle	Swimming at surface.

Table3. Summary of Marine Mammal Sightings

Date	Independent MMO Sightings	Independent Navy Lookout Team Sightings	Sightings by both Teams
12 Nov	0	0	0
13 Nov	1	1	0
14 Nov	0	0	0
15 Nov	0	0	0
16 Nov	1	0	1
Total	**2**	**1**	**1**

All marine mammal sightings were considered trials for the lookout effectiveness study. However, given the low number of sightings (3), the average number of trials per hour over the duration of the exercise was 0.09 (Table 4). This trial rate was the lowest average obtained to date as part of the lookout effectiveness study. Two of the marine mammal sightings could be identified to species (Table 5): spinner dolphin (*Stenella longirostris*) and spotted dolphin (*Stenella attenuata*). The third sighting, unidentified balaenopterid, could not be identified to species. Photographs were obtained for the spinner dolphins (Figure 2).

Table 4. Effort Hours, Sighting Rates, and Trial Rates

Date	Hours MMO Team Effort	# of Unique Sightings*	Sightings/ Hour	# of Trials	Trials/ Hour
12 Nov	5 hr 26 min	0	0	0	0
13 Nov	9 hr 37 min	1	0.10	1	0.10
14 Nov	8 hr 54 min	0	0	0	0
15 Nov	9 hr 19 min	0	0	0	0
16 Nov	1 hr 51 min	2	1.09	2	1.09
Total	**35 hr 07 min**	**3**	**0.09 (mean)**	**3**	**0.09 (mean)**

* Number of sightings includes both MMO and Navy lookout team sightings combined

Table 5. Unique sightings by species

Species	Unique animal group sightings	Total number of animals (based on best group size estimate)
Spinner dolphin	1	13
Spotted dolphin	1	35
Unidentified balaenopterid	1	1
Green sea turtle	4	4
Unidentified sea turtle	1	1
Total	**8**	**54**

The spinner dolphins were first observed by the starboard MMO as they rode the bow. They were soon observed by the port MMO and the bridge lookouts. The animals were in several small groups. They were observed bowriding and porpoising out of the water abeam of the port side. The last small group observed was of four animals and was riding the wave off the port beam. The entire period of observation was approximately 5 minutes. The ship did not implement any mitigation measures as the animals were bowriding. One calf was observed.

Figure 2. Photographs of spinner dolphin sighting

The spotted dolphins were observed at a distance of 2,055 ft (626 m) by the LMMO. The first cue was splashes and a bird flock. The dorsal fins were observed using binoculars about one minute after the bird flock and splashes were first observed. The subsequent observation of dorsal fins was the confirmation of marine mammals. The dolphins were observed swimming in a fairly tight group, weaving with frequent changes in direction. Given the presence of birds circling overhead and diving into the water and the back and forth swimming of the animals, the dolphins appeared to be feeding. At approximately the same time as the LMMO confirmation of dolphins with the birds, the LMMO heard the Chaplain point out the dolphins to the SMMO. The Chaplain was not on lookout duty and did not report the sighting to the bridge or lookouts. The lookout team did not see the animals during the entire sighting. The dolphins stayed in a fairly tight group, swimming back and forth and were associated with the birds for the entire sighting. They did not appear to change their behavior (e.g. to bowride) in response to the presence of the Navy vessel. The animals were lost off the starboard side after CG-A continued on course.

In addition to marine mammal and sea turtle sightings, 61 seabirds were recorded during this effort. Seabird sightings and identification were not an objective of this study, but were recorded when appropriate. Species observed included wedge-tail shearwater, brown booby, red-footed booby, masked booby, white tern, frigatebird, red-tailed tropicbird, and brown noddy, and unidentified shearwaters, petrels, and birds.

CONCLUSION

The goals of the lookout effectiveness monitoring effort are provided below, with a conclusion regarding each of the goals:

1. Collect data to determine the effectiveness of the Navy lookout team.

   The small number of sightings resulted in very limited data (i.e., trials) that can be used in determining the effectiveness of the Navy lookout team. The lack of sightings data, however, provides insight into species presence and composition in the area, which can be used for later analyses. This event is the first 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 Navy lookouts as a whole, rather than specific to each vessel.

2. Obtain data to characterize the possible exposure of marine species to MFAS.

   Sightings information included the bearing and distance of the animal to CG-A. This information can be used to determine, if MFAS was in use, what level the animal may have been exposed to MFAS. Reconstruction of the event and the determination of the possible exposures of marine species to MFAS will be completed under separate task. Obtaining the data needed to make these determinations was successful.

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APPENDIX H. Cruise Report, Marine Species Monitoring Effectiveness Study, Submarine Commanders Course 11-1 and Undersea Warfare Exercise, February 2011, Hawaii Range Complex

June 2011

Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study

Submarine Commanders Course 11-1 and Undersea Warfare Exercise

February 2011, Hawaii Range Complex

Prepared for:
Commander, U.S. Pacific Fleet

Prepared by:

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Dr. Thomas A. Jefferson – HDR
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LIST OF ACRONYMS AND ABBREVIATIONS

ft	foot (feet)
km	kilometer(s)
m	meter(s)
MFAS	mid-frequency active sonar
MMO	marine mammal observer
nm	nautical mile(s)
yd(s)	yard(s)

INTRODUCTION

In order to address requirements under the Marine Mammal Protection Act Letters of Authorization permitted to the U.S. Navy, three U.S. Navy civilian marine mammal observers (MMOs; Ms. Amy Farak, Ms. Julie Rivers, and Dr. Robert Uyeyama) and one U.S. Navy contractor (Dr. Thomas A. Jefferson) participated in two consecutive ASW exercise events in the Hawaii Range Complex from 15-22 February, 2011 (Figure 1). These MMOs were stationed aboard a U.S. Navy destroyer, hereafter referred to as DDG-D. The goals of the monitoring and this study were to:

1. Collect data to assess the effectiveness of the Navy lookout team.
2. Obtain data to characterize the possible exposure of marine species to mid-frequency active sonar (MFAS).
3. Achieve close coordination between the contracted aerial survey team, Navy aircraft on the range, range control, and the MMO team aboard DDG-D to facilitate maximizing survey time and project safety.

SHIPBOARD MONITORING

MMO surveys were conducted on a not-to-interfere basis, which means that the MMOs would not replace required Navy lookouts, would not dictate operational requirements/maneuvers, and would remove themselves from the bridge wing if necessary for DDG-D to accomplish its mission objectives. The exceptions would be if a marine mammal or sea turtle was sighted by the MMO within the shut-down zone during MFAS use (200 yards [yds], 183 meters [m]) and was not sighted by the Navy lookout team, or if the vessel was in danger of striking the marine species. In these cases, the MMO would report the sighting to the Navy lookout team for appropriate reporting and action.

The MMO survey on DDG-D was conducted on the bridge wings (elevated 66 feet [ft; 20 m] above the waterline), with two MMOs actively search for marine mammals and sea turtles, one MMO recording data, and one MMO acting as a liaison with the bridge team/lookouts to relay their sightings. Liaison MMO and recording MMO would also search while not otherwise engaged in their primary role. While on effort, MMOs used naked eye and 7 X 50 magnification binoculars to scan the area from dead ahead to just aft of the beam.

AERIAL MONITORING

Aerial surveys were conducted during the Submarine Commanders Course (16-18 February) under contract Contract #N62742-10-D-3011 CTO KB07, using similar methods as were used during the August 2008/09 and February 2009/10 surveys, including ship-following orbital tracks, shoreline surveys, and assisting in the pre-exercise tagging effort. The primary goals of the aerial monitoring were to locate and identify marine species before, during, and after the training event, and to monitor and report observations of their behavior. This included monitoring for any potentially injured or harmed marine species and any unusual behavior or changes in behavior, distribution, numbers, and species associations of animals observed during the training event. Communications between the survey aircraft and the MMO team aboard DDG-D were enabled by an aviation VHF radio handset brought by the MMO team.

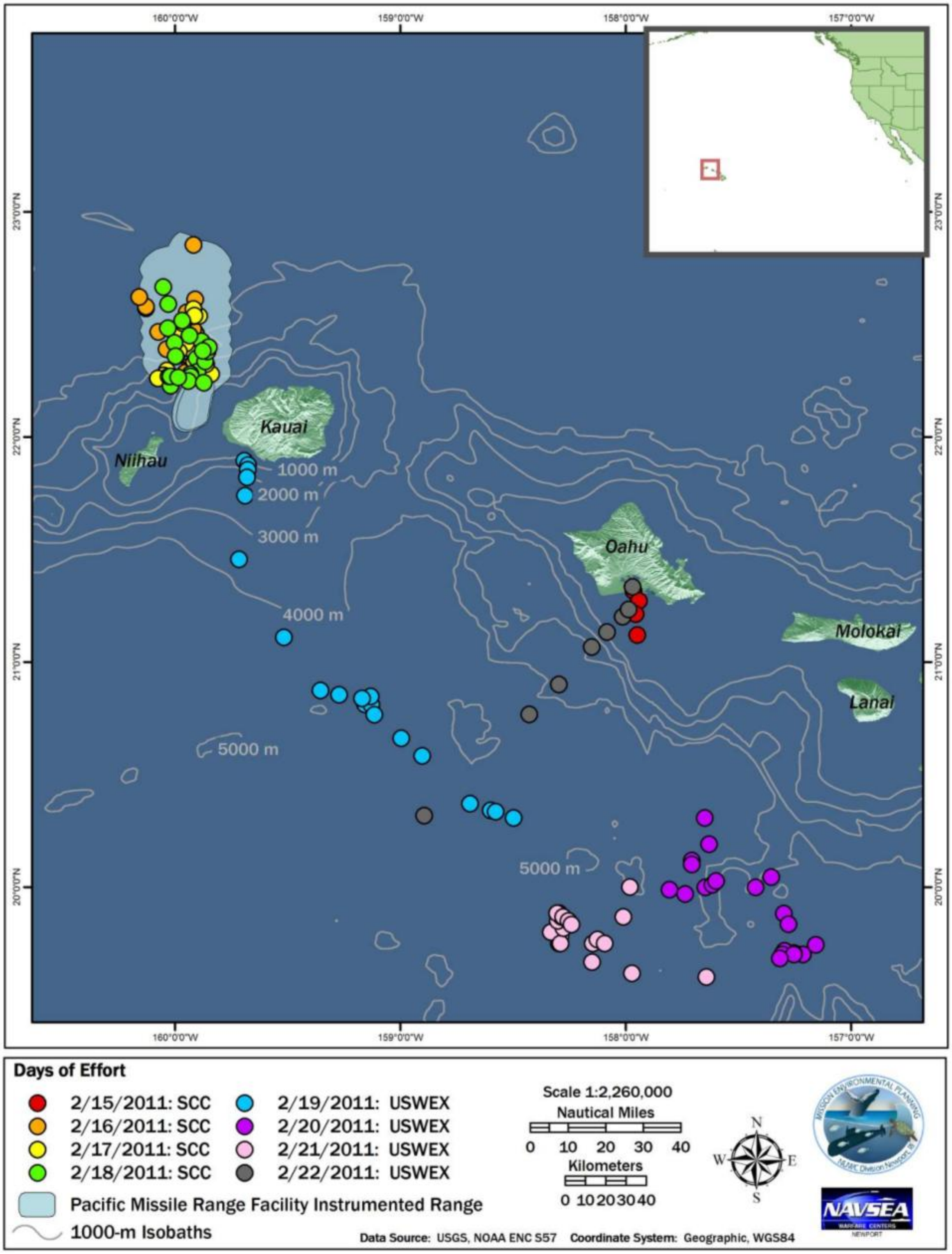

Figure 1. Location of MMO Effort

In addition to this Navy cruise report focusing on shipboard activities, the aerial survey contractor (Dr. Joseph Mobley, HDR) will provide a comprehensive scientific report detailing their methods, observations, and recommendations.

RESULTS

Shipboard Monitoring

Effort and environmental information was collected when the MMOs began effort, at each rotation, and as significant weather changes occurred. The MMO team spent 61 hours 31 minutes, and 10 seconds searching for marine species during the two training events (1). For all four observers, a total of 246 hours, 4 minutes, and 40 seconds of marine species shipboard monitoring was conducted. Beaufort Sea States ranged from 1 to 6, with the majority of the time occurring in Sea States 3 – 5 (Figures 2 and 3). Unexpectedly, periods of low sea states in offshore waters southwest of Oahu occurred on 19 February (Figure 4). This allowed for better sighting conditions and allowed for additional species identification. From 16 – 18 February, effort was located to the north and west of Kauai, whereas 20-21 February were spent south of Oahu; all other days were spent transiting to and from these areas.

Table 1. Effort Hours and Environmental Conditions

Date	Team Hours On-Effort	Beaufort Sea State (range)	% Cloud Cover	Visibility
15 Feb 11	58 min 20 sec	2 – 4	80 – 90	Excellent
16 Feb 11	9 hr 33 min 29 sec	3 – 6	70 – 100	Good – Moderate
17 Feb 11	9 hr 31 min 34 sec	5 – 6	70 – 100	Good – Moderate
18 Feb 11	9 hr 26 min 50 sec	2 – 6	15 – 75	Good – Moderate
19 Feb 11	9 hr 12 min 41 sec	1 – 4	60 – 90	Good – Moderate
20 Feb 11	9 hr 0 min 07 sec	3 – 6	25 – 95	Good – Moderate
21 Feb 11	8 hr 42 min 40 sec	3 – 5	30 – 100*	Poor – Moderate
22 Feb 11	4 hr 5 min 29 sec	3 – 4	25 – 50	Good
Total	**60 hr 31 min 10 sec** (242 hours, 4 minutes, 40 seconds for 4 observers)	**1 – 6**	**25 – 100**	**Poor – Good**

** rain encountered*

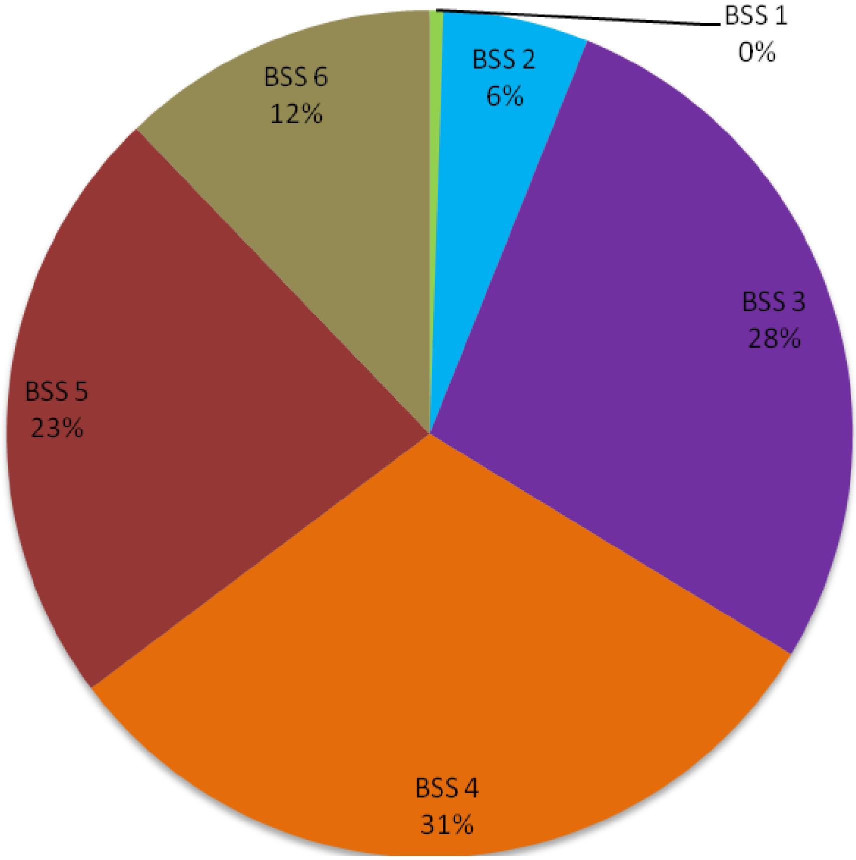

Figure 2. Total Percentage of Effort at Beaufort Sea States

In total, 35 sightings of marine mammals and one sea turtle were recorded during the eight days of observation (Table 4 and Figure 5). Two sightings (sighting numbers 34 and 35) were made by the Navy lookout team during entry into port. The MMOs, however, question the validity of these data points, as the lookout making the sighting was not a normal lookout, he was focused on obtaining bearings to landmarks for safe navigation, and the MMOs were not able to resight the animals, even when they were indicated as being close aboard the vessel. As such, these sightings data are included in Table , but are not included in the additional summary tables below.

Seventeen of the sightings were made independently by the MMOs, that is, not seen by the Navy lookout team (Table 2). Additionally, five sightings were made by the Navy lookout team but were not sighted by the MMOs and species information could not be obtained. Eighteen sightings were identifiable to species; one sighting each of Risso's dolphin (*Grampus griseus*), spinner dolphin (*Stenella longirostris*), striped dolphin (*Stenella coeruleoalba*), pilot whale (*Globicephala macrorhynchus*), and green turtle (*Chelonia mydas*), and 13 sightings of humpback whales (*Megaptera novaeangliae*; Table 3).

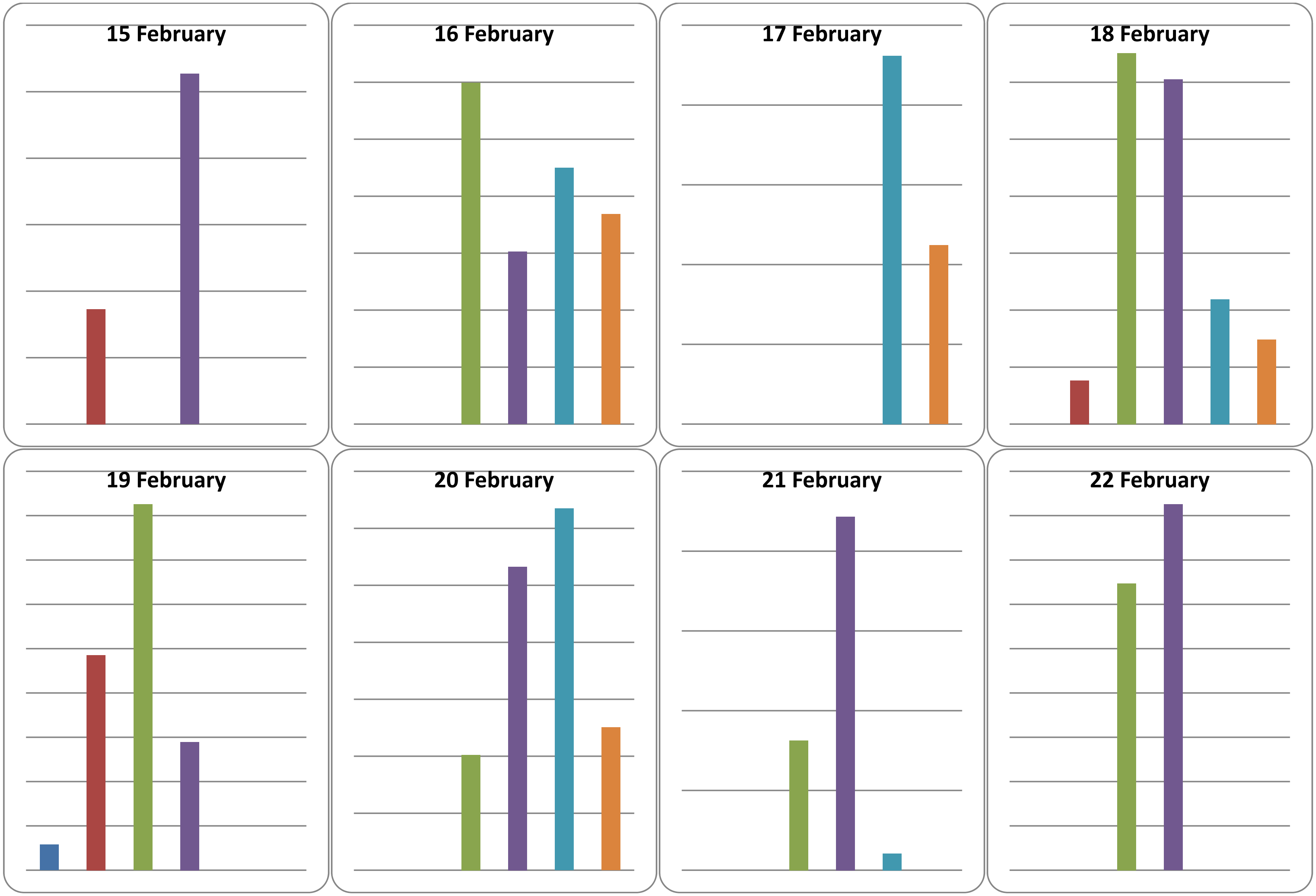

Figure 3. Daily Percentage of Effort at Beaufort Sea States

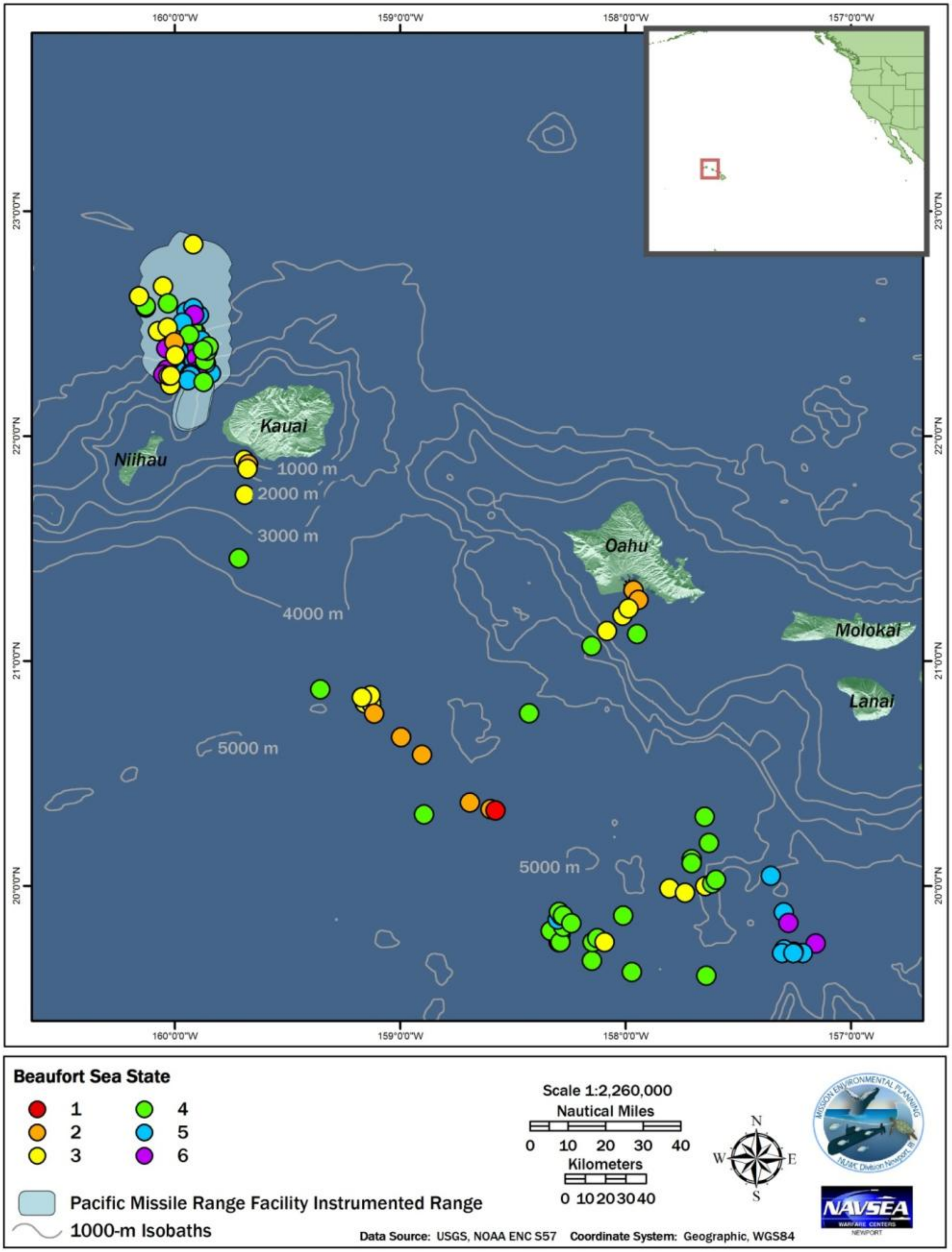

Figure 4. Beaufort Sea State at Effort Locations

Table 2. Marine Mammal and Sea Turtle Sightings by Observer

Date	Independent MMO Sightings	Independent Navy Lookout Team Sightings	Sightings by both Teams
15 Feb	0	1	4
16 Feb	3	0	0
17 Feb	4	0	1
18 Feb	4	2	3
19 Feb	3	1	2
20 Feb	1	0	0
21 Feb	0	0	0
22 Feb	2	1	2
Total	**17**	**6**	**11**

Table 3. Unique sightings by species

Species	Unique animal group sightings	Total number of animals (based on best group size estimate)
Risso's dolphin	1	40
Spinner dolphin	1	45
Striped dolphin	1	23
Pilot whale	1	18
Humpback whale	13	27
Unidentified *Stenella* sp.	1	10
Unidentified small cetacean	1	10
Unidentified balaenopterid	2	3
Unidentified whale	12	16
Green sea turtle	1	1
Total	**34**	**176**

Table 4. Marine Mammal and Sea Turtle Sightings

Data Category	Sighting 1	Sighting 2	Sighting 3	Sighting 4	Sighting 5	Sighting 6	Sighting 7
Sightings Information							
Effort (on/off)	On	On	On	On	On	On	On
Date	2/15/2011	2/15/2011	2/15/2011	2/15/2011	2/15/2011	2/16/2011	2/16/2011
Time	153707	154005	154210	154323	154456	140623	140747
Location	21.3029 -157.9581	21.2926 -157.9524	21.2855 -157.9485	21.2813 -157.9463	21.2813 -157.9463	22.2749 -159.9529	22.2774 -159.9188
Detection Sensor	MMO & Bridge	Bridge	MMO & Bridge	MMO & Bridge	MMO & Bridge	MMO	MMO
Species/Group	Humpback whale	Humpback whale	Humpback whale	Humpback whale	Spinner dolphin	Humpback whale	Humpback whale
Group Size (min/max/best)	2/2/2	1/1/1	3/3/3	1/1/1	40/60/45	1/1/1	1/1/1
# Calves							
Bearing (rel)	20	340	15	25	10	335	345
Distance (m)	5624.45	2011.68	4297.25	3502.28	4297.25	6729.16	15857.29
Environmental Information							
Wave height (ft)	< 3 ft	< 3 ft	< 3 ft	< 3 ft	< 3 ft	> 6 ft	> 6 ft
Visibility	Excellent	Excellent	Excellent	Excellent	Excellent	Moderate	Moderate
BSS	2	2	2	2	2	6	6
% cloud cover	80	80	80	80	80	100	100
% glare						0	0
Operational Information							
Sonar on/off	Off	Off	Off	Off	Off	On	On
Ship bearing (true)						45	45
Animal motion	None		None	None	Closing		
Sighting Cue/ Behavior	Saw 2 blows twice separated by a couple seconds. Animals were traveling	Blow	Saw blow, some surface activity. Animals dove as we approached.	Traveling	Bow riding	Blow	Breaching
Mitigation implemented	None	None	None	None	None	None	None
Comments							

Table 4 (cont). Marine Mammal and Sea Turtle Sightings Information

Data Category	Sighting 8	Sighting 9	Sighting 10	Sighting 11	Sighting 12	Sighting 13	Sighting 14
Sightings Information							
Effort (on/off)	On	On	On	On	On	On	On
Date	2/16/2011	2/17/2011	2/17/2011	2/17/2011	2/17/2011	2/17/2011	2/18/2011
Time	144227	073909	081044	084318	163711	173426	094749
Location	22.3108 -159.9416	22.4286 -159.9663	22.3667 -159.9021	22.2226 -159.8471	22.3145 -160.0236	22.2359 -160.0426	22.2990 -159.8759
Detection Sensor	MMO	MMO	MMO	MMO	MMO	Lookout	MMO & Bridge
Species/Group	Unidentified whale	Unidentified whale	Unidentified whale	Unidentified whale	Unidentified balaenopterid	Unidentified whale	Humpback whale
Group Size (min/max/best)	2/3/2	3/5/4	1/1/1	1/1/1	2/2/2	1/1/1	4/5/4
# Calves							
Bearing (rel)	40	20	270	50	90	278	5
Distance (m)	6118.88	3349.49	4297.25	5624.45	4297.25	804.67	3502.28
Environmental Information							
Wave height (ft)	> 6 ft	4 – 6 ft	4 – 6 ft	4 – 6 ft	4 – 6 ft	4 – 6 ft	4 – 6 ft
Visibility	Moderate	Good	Good	Good	Moderate	Moderate	Moderate
BSS	6	5	5	5	5	6	4
% cloud cover	100	75	80	80	100	100	60
% glare	0	0	25	25	0	0	0
Operational Information							
Sonar on/off	On	On	Off	Off	Off	Off	On
Ship bearing (true)	270	180		47	209	32	15
Animal motion		None	None	None	None		
Sighting Cue/ Behavior	Blow	At least 3 bushy, angled blows.	Blow	Blow	Blow	Small, whale-sized head sticking out of water.	Multiple blows, animals fluked.
Mitigation implemented	None	None	None	None	None	None	Bridge slowed upon initial sighting, and subsequently turned off sonar.
Comments	Potentially the same animal as sighting 7.	Unknown if angled blow was due to wind. Likely humpback or sperm whales.			Probable humpback whale	Saw with naked eye. Possible minke based on description.	Changed travel direction, split into two groups and dove under us as ship approached*

* see raw data sheets for detailed behavioral observations for this sighting

Table 4 (cont). Marine Mammal and Sea Turtle Sightings Information

Data Category	Sighting 15	Sighting 16	Sighting 17	Sighting 18	Sighting 19	Sighting 20	Sighting 21
Sightings Information							
Effort (on/off)	On	On	On	On	On	On	On
Date	2/18/2011	2/18/2011	2/18/2011	2/18/2011	2/18/2011	2/18/2011	2/18/2011
Time	095827	101134	105832	130944	142612	151134	171121
Location	22.3244 -159.8681	22.3648 -159.8757	22.3709 -159.8668	22.6786 -160.0604	22.5441 -160.0344	22.4620 -160.0066	22.2279 -160.0463
Detection Sensor	Bridge	Bridge	MMO	MMO	MMO	MMO & Bridge	MMO & Lookout
Species/Group	Unidentified whale	Unidentified whale	Unidentified whale	Unidentified whale	Unidentified whale	Pilot whale	Humpback whale
Group Size (min/max/best)		1	1/2/1	1/1/1	2/2/2	12/30/18	2/3/2
# Calves							
Bearing (rel)	port bow	20	271	340	340	355	80
Distance (m)	1828.8	9144	6729.16	4297.25	732.71	1623.53	2343.29
Environmental Information							
Wave height (ft)	4 – 6 ft	4 – 6 ft	4 – 6 ft	< 3 ft	4 – 6 ft	< 3 ft	< 3 ft
Visibility	Moderate	Moderate	Good	Good	Moderate	Good	Good
BSS	4	4	4	3	4	3	3
% cloud cover	60	60	0	70	25	40	45
% glare	0	0	75	0	70	60	25
Operational Information							
Sonar on/off	On	On	Off	Off	Off	Off	Off
Ship bearing (true)		80	293	333	181	turning	
Animal motion			None		None	None	Parallel
Sighting Cue/ Behavior		Blow	Blow	Blow	Blow	resting	Traveling
Mitigation implemented	None	None	None	None	None	None	None
Comments							

Table 4 (cont). Marine Mammal and Sea Turtle Sightings Information

Data Category	Sighting 22	Sighting 23	Sighting 24	Sighting 25	Sighting 26	Sighting 27
Sightings Information						
Effort (on/off)	On	On	On	On	On	On
Date	2/18/2011	2/19/2011	2/19/2011	2/19/2011	2/19/2011	2/19/2011
Time	173349	071041	092419	093604	095943	165504
Location	22.2680 -160.0411	21.8983 -159.6893	21.3597 -159.7108	21.3093 -159.6861	21.2026 -159.6281	20.4026 -158.7243
Detection Sensor	MMO	MMO & Lookout	Lookout	MMO	MMO	MMO & Lookout
Species/Group	Humpback whale	Humpback whale	Unidentified whale	Unidentified *Stenella* sp.	Unidentified balaenopterid	Striped dolphin
Group Size (min/max/best)	1/1/1	4/4/4	1	5/20/10	1/1/1	15/30/23
# Calves		1				
Bearing (rel)	65	356	355	110	20	330
Distance (m)	6118.88			1623.53	4862.98	1623.53
Environmental Information						
Wave height (ft)	< 3 ft	< 3 ft	< 3 ft	< 3 ft	< 3 ft	< 3 ft
Visibility	Good	Moderate	Good	Good	Good	Good
BSS	3	2	4	4	4	2
% cloud cover	45	95	60	60	60	90
% glare	25	0	20	20	20	5
Operational Information						
Sonar on/off	Off	Off	Off	Off	Off	Off
Ship bearing (true)	90	100	182	154	133	108
Animal motion	None	Parallel		Parallel		Parallel
Sighting Cue/Behavior	Blow	Animals were observed resting at the surface. Two animals fluked up but came right back to same spot. At end of sighting, animals were slowly traveling northward along coast.	Saw blow and fluke.	Splashes, small *Stenella* sized bodies observed	Tall, thin blow at initial distance, then a flukeprint and a less distinguished blow observed past the beam.	Porpoising
Mitigation implemented	None	None	Ship turned immediately to 152 deg, unknown if it was a result of the whale sighting or tactical maneuvers.		None	None
Comments					Likely blue, fin, or sei whale; 99% sure not a humpback.	

Table 4 (cont). Marine Mammal and Sea Turtle Sightings Information

Data Category	Sighting 28	Sighting 29	Sighting 30	Sighting 31	Sighting 32	Sighting 33
Sightings Information						
Effort (on/off)	On	On	On	On	On	On
Date	2/19/2011	2/20/2011	2/22/2011	2/22/2011	2/22/2011	2/22/2011
Time	174633	084717	125707	131453	134530	135538
Location	20.3223 -158.5413	20.0198 -157.7719	21.2141 -158.0171	21.2179 -158.0123	21.2586 -157.9580	23.7744 -157.9386
Detection Sensor	MMO	MMO	MMO	Bridge	MMO & Lookout	MMO
Species/Group	Risso's dolphin	Unidentified small cetacean	Humpback whale	Unidentified whale	Unidentified whale	Humpback whale
Group Size (min/max/best)	32/50/40	5/20/10	3/4/3	1	1	2/2/2
# Calves						
Bearing (rel)	340	70	50	110	350	40
Distance (m)	3210.01	5624.45	6729.16	2040.56	182.88	4297.25
Environmental Information						
Wave height (ft)	< 3 ft	4 – 6 ft	< 3 ft	< 3 ft	< 3 ft	< 3 ft
Visibility	Good	Good	Good	Good	Good	Good
BSS	1	4	3	3	3	3
% cloud cover	90	40	50	45	45	45
% glare	0	15	0	0	0	0
Operational Information						
Sonar on/off	Off	Off	Off	Off	Off	Off
Ship bearing (true)	110	238	58		60	
Animal motion	Parallel	None				
Sighting Cue/ Behavior	Saw bodies, animals were milling	Saw splashes and body.	Blow, resting at surface	Blow	Blow	Blow, animals traveling
Mitigation implemented		None	None	None	None	None
Comments	Black, smallish body, tall dorsals, 3 m long, blunt head; everything consistent with Risso's. Animals milling in loose dispersed group; at one point some were coming out of water more as if to bow ride, but then didn't. Some porpoised out of water, saw one leap out of water; most animals darker coloration, but some were whiteish.	Vessel was maneuvering, could not resight the animals.		Distance not provided by bridge personnel, estimated by MMO after sighting.		

Table 4 (cont). Marine Mammal and Sea Turtle Sightings Information

Data Category	Sighting 34	Sighting 35	Sighting 36
Sightings Information			
Effort (on/off)	On	On	On
Date	2/22/2011	2/22/2011	2/22/2011
Time	135819	140349	140349
Location	21.2821 -157.9459	21.3014 -157.9573	21.3014 -157.9573
Detection Sensor	Lookout	Lookout	MMO & Lookout
Species/Group	Unidentified whale	Unidentified whale	Green turtle
Group Size (min/max/best)	1	2	1/1/1
# Calves			
Bearing (rel)	45	170	70
Distance (m)	137.16	2754.73	15.24
Environmental Information			
Wave height (ft)	< 3 ft	< 3 ft	< 3 ft
Visibility	Good	Good	Good
BSS	3	3	3
% cloud cover	45	45	45
% glare	0	0	0
Operational Information			
Sonar on/off	Off	Off	Off
Ship bearing (true)		330	330
Animal motion			
Sighting Cue/ Behavior	Blow	Blow	Swimming, dove when reached abeam.
Mitigation implemented	None	None	None
Comments	Animal was not resighted by MMO; as sighting happened while entering port, lookouts were focused on obtaining bearings to landmarks, and different lookouts where on watch, we are unsure if this sighting was actually an animal. Data point not included in future summaries.	Animals were not resighted by MMO; as sighting happened while entering port, lookouts were focused on obtaining bearings to landmarks, and different lookouts where on watch, we are unsure if this sighting was actually an animal. Data point not included in future summaries	

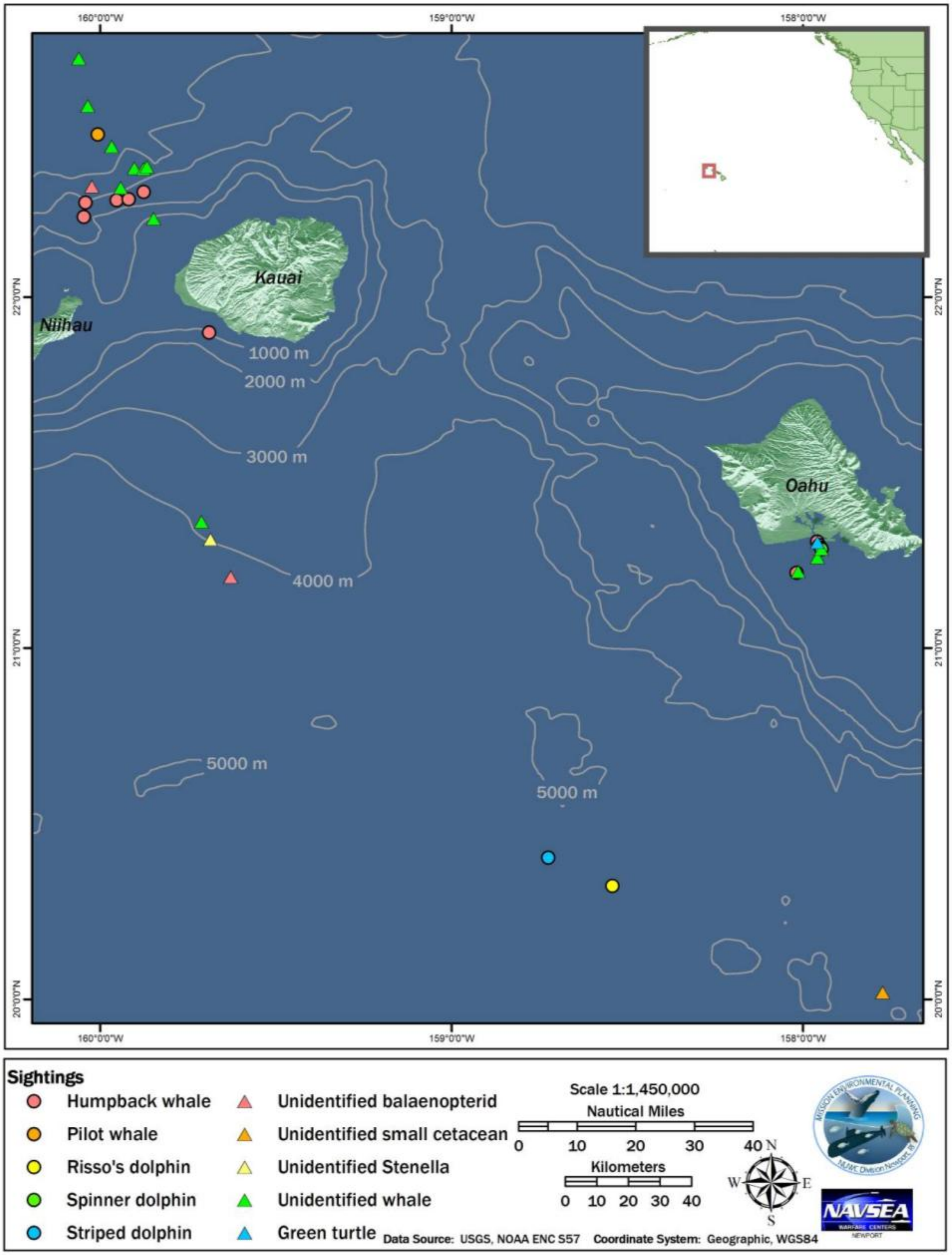

Figure 5. Marine Mammal and Sea Turtle Sighting Locations

Twenty-three of the sightings (68%) were considered trials for the lookout effectiveness study. Trials were conducted on all but one day of the study, for an average rate of 0.38 trials per hour across all eight days (Table 5).

Table 5. Effort Hours, Sighting Rates, and Trial Rates

Date	Hours MMO Team Effort	# of Unique Sightings*	Sightings/ Hour	# of Trials	Trials/Hour
15 Feb	58 min 20 sec	5	5.14	4	4.11
16 Feb	9 hr 33 min 29 sec	3	0.31	3	0.31
17 Feb	9 hr 31 min 34 sec	5	0.52	4	0.42
18 Feb	9 hr 26 min 50 sec	9	0.95	6	0.64
19 Feb	9 hr 12 min 41 sec	6	0.65	4	0.43
20 Feb	9 hr 0 min 07 sec	1	0.11	1	0.11
21 Feb	8 hr 42 min 40 sec	0	0.00	0	0.00
22 Feb	4 hr 5 min 29 sec	5	1.22	1	0.24
Total		**34**	**0.56**	**23**	**0.38**

* Number of sightings includes both MMO and Navy lookout team sightings combined

Of particular interest was sighting 14, as behavioral information was able to be gathered while active sonar was in use. Initial sighting of a group of 4 humpback whales was observed approximately 3800 yds (3500 m) from the vessel at bearing 005° relative (as recorded by the MMOs). On the fourth resight of the animals by the MMOs, the bridge team also sighted the animals at an estimated distance of 2000 yds (1800 m) (Note: at the same time, MMO noted the animals at 3 reticles (1154 m) off the starboard bow. Immediately upon sighting the animals, the ship slowed speed to steerage, and called down for CIC to halt active sonar. On the animals' fifth surfacing, the animals had turned sharply away from the vessel, but on the sixth surfacing, turned 180° towards the vessel and dove under the bow of the ship. Two minutes later, the cow calf pair were observed surfacing about 100 yds (91 m) off the port beam and the other two animals were observed about 300 yds (182 m) astern of the vessel. The entire sighting duration was 8 minutes and 18 seconds.

In addition to marine mammal and sea turtle sightings, 93 seabirds were recorded during this effort (Table 6 and Figure 6). Seabird sightings were not recorded if identification at least to family level was not possible. Because seabird data collection was not an objective of this study, data was only collected when it would not interfere with marine mammal data collection. Species observed included Laysan albatross, Red-footed booby, brown booby, black-footed albatross, white-tailed tropicbird, gadfly petrel, gadfly petrel, sooty tern, white tern, and various unidentified birds.

Table 6. Bird Sightings

Date	Sighting Number	Time	Species	Group Size	Location	
15 Feb	1	175611	Tropicbird		21.19842	-157.9591
16 Feb	2	082157	Laysan albatross	1/1/1	22.41833	-159.9656
16 Feb	3	084209	Red-footed booby	1/1/1	22.37158	-159.9337
16 Feb	4	091727	Laysan albatross	1/1/1	22.39036	-159.9380
16 Feb	5	093111	Brown booby	1/1/1	22.42553	-159.9718
16 Feb	6	110035	Booby	1/1/1	22.56667	-160.1281
16 Feb	7	114204	Laysan albatross	3/3/3	22.59389	-160.1658
16 Feb	8	114230	Booby	1/1/1	22.59583	-160.1661
16 Feb	9	133014	Albatross (probable Laysan)		22.35003	-159.9823
16 Feb	10	144828	Red-footed booby		22.32369	-159.9391
16 Feb	11	162954	Laysan albatross		22.46186	-159.9191
16 Feb	12	165131	Black-footed albatross		22.5085	-159.9187
16 Feb	13	172153	Red-footed booby		22.58611	-159.9179
17 Feb	14	072514	Red-footed booby	1/1/1	22.45708	-159.9735
17 Feb	15	073410	Red-footed booby	1/1/1	22.43989	-159.9659
17 Feb	16	074645	Laysan albatross	1/1/1	22.41072	-159.9593
17 Feb	17	082900	Red-footed booby	1/1/1	22.28469	-159.8555
17 Feb	18	090102	Red-footed booby and tropicbird	1 each	22.27064	-159.8378
17 Feb	19	091651	Laysan albatross	1/1/1	22.30983	-159.8790
17 Feb	20	091752	Laysan albatross	2/2/2	22.31222	-159.8819
17 Feb	21	092033	White-tailed tropicbird	1/1/1	22.31483	-159.8909
17 Feb	22	093216	Laysan albatross	1/1/1	22.32406	-159.9278
17 Feb	23	094403	Red-footed booby	1/1/1	22.34608	-159.9534
17 Feb	24	094550	Tropicbird	1/1/1	22.34708	-159.9480
17 Feb	25	111852	Red-footed booby	1/1/1	22.36817	-159.9216
17 Feb	26	131404	Black-footed booby	1/1/1	22.54967	-159.9033
17 Feb	27	162818	Laysan albatross	1/1/1	22.33133	-160.0128
17 Feb	28	163222	Red-footed booby	3/3/3	22.32292	-160.0182
17 Feb	29	163222	Gadfly petrel	1/1/1	22.32292	-160.0182
17 Feb	30	165547	Laysan albatross	1/1/1	22.28331	-160.0436
17 Feb	31	172256	Laysan albatross	1/1/1	22.23558	-160.0579

Date	Sighting Number	Time	Species	Group Size	Location	
17 Feb	32	174744	Black-footed albatross	1/1/1	22.25719	-160.0433
18 Feb	33	074629	Red-footed booby	1/1/1	22.39322	-159.8907
18 Feb	34	075345	Laysan albatross	1/1/1	22.37947	-159.8951
18 Feb	35	075611	Red-footed booby	1/1/1	22.37261	-159.8997
18 Feb	36	080817	Laysan albatross	1/1/1	22.33361	-159.9035
18 Feb	37	081520	Red-footed booby	1.1.1	22.26111	-159.9079
18 Feb	38	083450	Laysan albatross	1/1/1	22.29328	-159.9175
18 Feb	39	093043	Laysan albatross	1/1/1	22.23547	-159.8653
18 Feb	40	093600	Red-footed booby	1/1/1	22.25275	-159.8690
18 Feb	41	093700	Laysan albatross	1/1/1	22.25689	-159.8667
18 Feb	42	103650	Red-footed booby	1/1/1	22.39239	-159.8491
18 Feb	43	104359	Black-footed albatross	1/1/1	22.38467	-159.8516
18 Feb	44	111451	Frigatebird	1/1/1	22.40414	-159.8907
18 Feb	45	113031	Red-footed booby	1/1/1	22.44219	-159.9270
18 Feb	46	113251	Red-footed booby	2/2/2	22.44819	-159.9327
18 Feb	47	130445	Red-footed booby	3/3/3	22.66494	-160.0511
18 Feb	48	141308	Black-footed albatross	1/1/1	22.57042	-160.0347
18 Feb	49	164731	Red-footed booby	1/1/1	22.23097	-159.9903
18 Feb	50	172106	Red-footed booby	1/1/1	22.24142	-160.0559
18 Feb	51	175832	Laysan albatross	1/1/1	22.26414	-159.9815
19 Feb	52	072316	Tropicbird	1/1/1	21.88764	-159.6763
19 Feb	53	073754	Tropicbird	3/3/3	21.84258	-159.6781
19 Feb	54	082609	Red-footed booby	1/1/1	21.62922	-159.7015
19 Feb	55	084415	Red-footed booby	2/2/2	21.5465	-159.7112
19 Feb	56	094530	White-tailed tropicbird		21.26786	-159.6662
19 Feb	57	100607	White-tailed tropicbird	1/1/1	21.17733	-159.6003
19 Feb	58	101125	White-tailed tropicbird	1/1/1	21.15731	-159.5757
19 Feb	59	121057	Unidentified albatross	1/1/1	20.811	-159.1418
19 Feb	60	133451	White-tailed tropicbird	1/1/1	20.81342	-159.1201
19 Feb	61	141155	Red-footed booby	5/5/5	20.84639	-159.1885
19 Feb	62	143429	Booby	4/4/4	20.84642	-159.1961
19 Feb	63	153543	Brown booby	2/2/2	20.66133	-158.9955

Date	Sighting Number	Time	Species	Group Size	Location	
19 Feb	64	155701	Sooty terns, dark shearwaters (unknown species), frigatebird	25/45/35	20.59542	-158.9168
20 Feb	65	074609	Frigatebird	1/1/1	20.16344	-157.6577
20 Feb	66	081217	Laysan albatross	1/1/1	20.09725	-157.7113
20 Feb	67	081526	Frigatebird	1/1/1	20.09161	-157.7160
20 Feb	68	105646	Shearwater	1/1/1	20.00678	-157.4329
20 Feb	69	144716	Frigatebird	1/1/1	19.70592	-157.2277
21 Feb	70	072001	Red-footed booby	1/1/1	19.62458	-157.9643
21 Feb	71	074338	Sooty tern	30/50/40	19.15917	-158.0626
21 Feb	72	074855	Buller's Shearwater	1/1/1	19.65717	-158.0859
21 Feb	73	075849	Sooty Tern	6/6/6	19.66903	-158.1299
21 Feb	74	081559	Unidentified tropicbird	1/1/1	19.69011	-158.2057
21 Feb	75	082333	Sooty tern	15/20/18	19.69972	-158.2397
21 Feb	76	082949	Red-footed booby & Sooty tern	35/50/45	19.70767	-158.2678
21 Feb	77	095029	Sooty tern	1/1/1	19.85894	-158.2930
21 Feb	78	114720	Red-footed booby	1/1/1	19.78878	-158.2834
21 Feb	79	133845	Red-footed booby	1/1/1	19.88253	-158.2843
21 Feb	80	153535	Red-footed booby	1/1/1	19.80322	-158.1905
21 Feb	81	165532	Red-footed booby	2/2/2	19.75808	-158.1070
22 Feb	82	103305	Sooty tern	6/6/6	20.61481	-158.5685
22 Feb	83	104053	Red-footed booby	1/1/1	20.65536	-158.5321
22 Feb	84	104501	Tropicbird	1/1/1	20.67686	-158.6629
22 Feb	85	112705	Tropicbird	3/3/3	20.89217	-158.3138
22 Feb	86	121253	White tern (aka fairy tern)	6/6/6	21.08514	-158.1498
22 Feb	87	121253	Frigatebird	1/1/1	21.08514	-158.1498
22 Feb	88	121905	White tern (aka fairy tern)	1/1/1	21.10631	-158.1315
22 Feb	89	122905	White tern (aka fairy tern)	1/1/1	21.10631	-158.0914
22 Feb	90	122905	Sooty tern	2/2/2	21.10631	-158.0914
22 Feb	91	123123	Tropicbird	1/1/1	21.14728	-158.0820
22 Feb	92	124833	Red-footed booby	16/50/25	21.1935	-158.0275
22 Feb	93	133444	Red-footed booby	1/1/1	21.24503	-157.9803

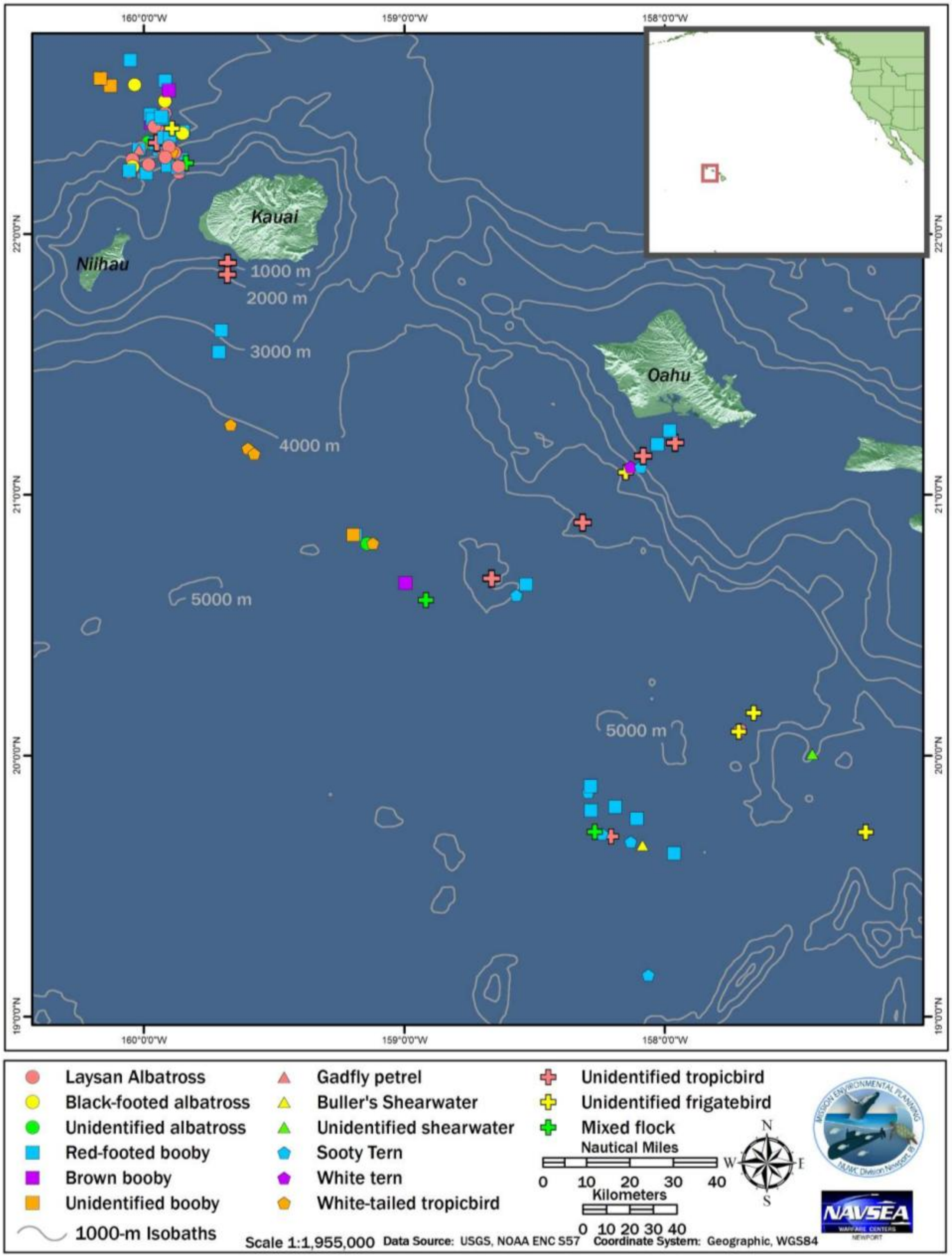

Figure 6. Bird Sighting Locations

AERIAL MONITORING

Sightings and focal follow information will be reported by the contractor under a separate report.

CONCLUSION

Marine Mammal Monitoring Goals

The goals of the lookout effectiveness monitoring effort are provided below, with a conclusion regarding each of the goals:

1. Collect data to determine the effectiveness of the Navy lookout team.

   The data collected provides the highest number of trials collected in Hawaiian waters. This event is the fourth aboard a DDG in which data were collected to determine effectiveness; data will be combined with future monitoring efforts in order to determine the effectiveness of Navy lookouts as a whole, rather than specific to each vessel.

2. Obtain data to characterize the possible exposure of marine species to MFAS.

   Sightings information included the bearing and distance of the animal to DDG-D. This information can be used to determine, if MFAS was in use, what level the animal may have been exposed to MFAS. Reconstruction of the event and the determination of the possible exposures of marine species to MFAS will be completed under separate task. Obtaining the data needed to make these determinations was successful.

3. Achieve close coordination between the contracted aerial survey team, Navy aircraft on the range, range control, and the MMO team aboard DDG-D to facilitate maximizing survey time and project safety

   Communication between the survey aircraft, MMOs, range control, and other aircraft was successful, maintaining safety of all participants.

APPENDIX I. Cruise Report, Marine Mammal Observer UNDET Monitoring Hawaii Range Complex, 26-27 April 2011

August 12, 2011

Final Cruise Report
Marine Mammal Observer UNDET Monitoring
Hawaii Range Complex, 26-27 April, 2011

Prepared for:
Commander, U.S. Pacific Fleet

Prepared by:

Robert K. Uyeyama, Ph.D.
Morgan W. Richie, M.A.
Naval Facilities Engineering Command, Pacific

List of Acronyms and Abbreviations

ft	Feet
HRC	Hawaii Range Complex
HST	Hawaii standard time
kts	Knots (nautical miles per hour)
LMDE	Limpet Mine Disposal Equipment
MDSU	Mobile Diving Salvage Unit
MFAS	Mid-frequency active sonar
MMO	Marine mammal observer
NEW	Net explosive weight
nm	Nautical miles
NMFS	National Marine Fisheries Service
PMAP	Protective Measures Assessment Protocol
RHIB	Rigid-hulled inflatable boat
RIMPAC	Rim of the Pacific, major training exercise
UNDET	Under-water detonation
VHF	Very high frequency
yd(s)	Yard(s)

1. INTRODUCTION

1.1 MONITORING PLAN

In order to train with mid-frequency active sonar (MFAS) and underwater explosives, the Navy has obtained a Letter of Authorization (permit) from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and a Biological Opinion under the Endangered Species Act. The Hawaii Range Complex (HRC) Monitoring Plan was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting will provide science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy MFAS. The objectives of the monitoring plan are to answer the following questions:

1. Are marine mammals and sea turtles exposed to MFAS at regulatory thresholds of harm or harassment? If so, at what levels and how frequently are they exposed?
2. If marine mammals and sea turtles are exposed to MFAS in the HRC, do they redistribute geographically in the HRC as a result of repeated exposure? If so, how long does the redistribution last?
3. If marine mammals and sea turtles are exposed to MFAS, what are their behavioral responses? Are they different at various levels?
4. What are the behavioral responses of marine mammals and sea turtles that are exposed to various levels and distances from explosives?
5. Are the Navy's suite of mitigation measures for MFAS and explosives (e.g., Protective Measures Assessment Protocol [PMAP], measures agreed to by the Navy through permitting and consultation) effective at avoiding harm or harassment of marine mammals and sea turtles?

The Marine Mammal Observers (MMO) effort is intended to address questions 4 and 5.

1.2 UNDERWATER DEMOLITION

Purpose—To provide training in the identification and destruction or neutralization of inert ground mines, floating/moored mines, harbor clearance, and excess ship hulks.

Description—Underwater demolition exercises include training in the detection and explosive attack of inert, underwater mines, as well as harbor clearance. Tactics against ground or bottom mines involve the diver placing a specific amount of explosives, which when detonated underwater at a specific distance from a mine results in neutralization of the mine. Floating, or moored, mines involve the diver placing a specific amount of explosives directly on the mine. Harbor clearance activities involve the diver placing a specific amount of explosives on underwater structures in order to clear these structures from their current position in the water column.

Location—The activities for this exercise took place offshore in the Pu'uloa Underwater Range (Danger Zone 334.1370, also called Keahi Point in prior RIMPAC Environmental Assessments), Pearl Harbor.

Duration—Each demolition activity generally lasts 1 to 4 hours.

Standard Procedures—All demolition activities are conducted in accordance with Commander Naval Surface Forces Pacific (COMNAVSURFPAC) Instruction 3120.8D, Procedures for Disposal of Explosives at Sea/Firing of Depth Charges and Other Underwater Ordnance (Department of the Navy, 1993). Before any explosive is detonated, divers are transported a safe distance away from the explosive and a thorough search is made of the area to identify marine mammals or sea turtles. If any are seen, the exercise is delayed until the animals leave the area. Specifically, all mitigation measures as described in the MMPA permit and Hawaii Range Complex EIS are followed. Standard practices for tethered mines in Hawaiian waters require ground mine explosive charges to be suspended 3 meters (10 feet) below the surface of the water. For mines on the shallow water floor (less than 40 feet of water), only sandy areas that avoid/minimize potential impacts to coral would be used for explosive charges.

2. METHODS

2.1 MARINE MAMMAL OBSERVERS

MMO monitoring was conducted from a shipboard platform that accompanied the exercises on site at the Pu'uloa Underwater Range (Danger Zone 334.1370). For the monitoring during 26-27 April 2011, a 27' Boston Whaler less provided and piloted by personnel of Mobile Diving Salvage Unit One (MDSU-1) was dedicated to the monitoring effort. There were two MMOs on board, each equipped with a pair of 7x50 binoculars, watch, and access to VHF communications with the other boats. One MMO was the data recorder as well as a secondary observer, and was equipped with a clipboard with data entry sheets (Table 1) and a handheld chart-plotting marine GPS unit. The MMOs were on effort throughout the duration of the day, from the time of the vessel leaving the dock, until its return.

All sightings by MMOs and Navy lookouts were recorded, as well as whether mitigation measures were followed. Monitoring surveys from other platforms were not conducted for these UNDET monitoring efforts.

2.2 COMMUNICATIONS

Communication between MMOs and MDSU-1, and the other participating vessels (see "Results" below) were performed via VHF radio or direct communication with Navy personnel on the boat.

3. RESULTS

A total of four underwater detonation (UNDET) events were monitored: Two UNDETs on each day during the 26-27 April training exercise by MDSU-1 in the Pu'uloa Underwater Range for a total observation time of 5 hours 34 minutes.

3.1 PARTICIPANTS AND LOCATION

Navy Biologist observers:

Julie Rivers - Commander, Pacific Fleet (CPF) – April 26-27

Robert Uyeyama – Naval Facilities Engineering Command Pacific (NAVFAC PAC) – April 26

Morgan Richie - Naval Facilities Engineering Command Pacific (NAVFAC PAC) – April 26, 27

Naval Dive Team:

US Navy - Mobile Diving Salvage Unit One (MDSU-1)

Vessels Involved in UNDET exercise:

2X RHIB ~24 ft

1X 27 ft Boston Whaler - (Carrying three Navy MDSU-1 personnel and two Navy Biologist MMOs)

Location:

Pu'uloa Underwater Range (*Danger Zone 334.1370, also called Keahi Point in prior RIMPAC Environmental Assessments)*

3.2 DESCRIPTION OF ACTIVITY

MDSU-1 performed two underwater detonation (UNDET) events each day on 26 and 27 April 2011, for a total of four events, in the Pu'uloa Underwater Range, approximately 1.7 nm from Keahi Point located west of the Pearl Harbor entrance channel. The intent of the exercises was to provide training for harbor clearance activities. The bottom depth of the training location was approximately 15 m.

The two UNDETs of 26 April contained a net explosive weight (NEW) of 3.64 lb., and 2.44 lb., and were located at were located approximately at 21.29492º N, 157.98775º W.

The two UNDETs of 27 April contained 6.038 lb, and 16.106 lb. NEW, and were located approximately at 21.29025º N, 157.98958º W.

On both days, a total of 3 boats participated: 2 RHIBs, as well as the Boston Whaler that was dedicated to the monitoring effort (Fig. 1) and carried the two Navy biologist observers in addition two three MDSU-1 personnel.

3.2.1 UNDETs of 26 April

The purpose of the exercise was harbor clearance. The simulated obstruction was composed of bar of metal embedded in a cement ballast and oriented vertically in the water. The training task was to shear the metal bar using an explosive charge placed by divers (Fig 5.) The monitoring vessel was one of three vessels at the training location, the other two being ~24 ft RHIBs operated by MDSU-1. Two underwater explosive events were monitored on this day. Both UNDET locations on this day were within the Pu'uloa Underwater Range at approximately 21.29492º N, 157.98775º W (Fig. 2).

No marine mammals or sea turtles were observed at the training location during the course of this day's monitoring effort for both events one and two, with the exception of a single sighting of a green sea turtle *(Chelonia mydas)* made during the return transit from the exercise, as described below under Event Two.

Figure 1. Navy biologist observer on Boston Whaler (left), and one of two participating RHIBs (right).

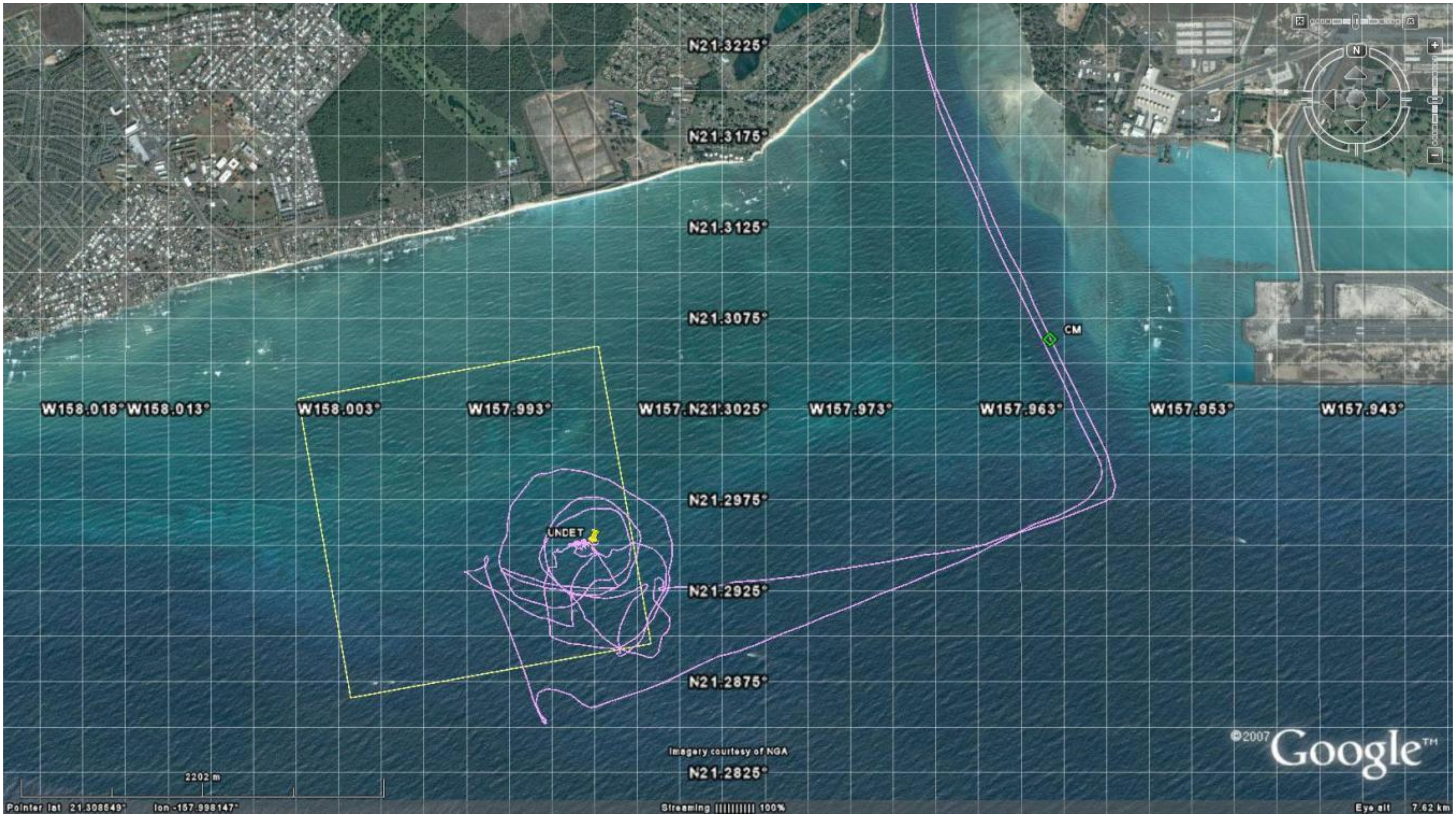

Figure 2. UNDET monitoring of 26 April 2011. The boundaries of the Pu'uloa Underwater range are marked by the yellow square. Monitoring vessel track shown in pink. The entrance to Pearl Harbor is at top. Sightings key: CM=Chelonia mydas.

EVENT ONE (NEW 3.64 lb): The monitoring vessel departed the dock within Pearl Harbor at 09:56, and arrived at the training location at 10:33. The sea state remained at Beaufort 4 throughout the day's effort, with a swell height up to 2 ft. Cloud cover was 15% and visibility was excellent throughout the exercise. No marine mammals or sea turtles were observed during the transit to the training location.

At 10:36 the exercise participants located an exercise buoy that had previously been deployed to mark the location of the simulated obstruction. At this time, the crew of the first RHIB proceeded to set the explosive charges on the simulated obstruction, while the pre-exercise mitigation survey for event one was begun by the second RHIB, which surveyed a roughly circular radius at a distance of approximately 250-600 yds (~225 - 550 m) (Fig. 3). The monitoring vessel also surveyed the same circular radius at a position approximately opposite ends such that the UNDET location was roughly at the midpoint between the two monitoring vessels and conducted a visual search to both starboard and port sides to cover the full mitigation range of 700m. At 11:07 the RHIBs switched positions: the first RHIB took over conducting the visual survey along the circular path, while the second RHIB moved to the UNDET location to place the blasting caps then connect and arm the radio-controlled detonation device. All communication radios were secured and the UNDET shot was triggered by the radio frequency device at 11:22. The pre-exercise mitigation survey for event one had therefore been conducted for 46 minutes. The post-exercise mitigation survey began at 11:26, again utilizing the same circular radius with one RHIB and the monitoring vessel on opposite sides of the circle, and was conducted for 35 minutes, ending at 12:01.

EVENT TWO (NEW 2.44 lb): The post-exercise survey for event one (beginning at 11:26) also served as the pre-exercise survey for event two. Again one RHIB set a charge while the other RHIB monitored, then the two vessels switched places to complete setting the blasting caps and arming the radio detonation device while the first vessel conducted monitoring. The UNDET shot was triggered by radio frequency device at 12:01. The pre-exercise mitigation survey for event two therefore had been conducted for 35 minutes (not including the 46-minute pre-exercise survey conducted for event one). After detonation (Fig. 4), the crews of both RHIBs retrieved floating debris composed of small sections of plastic bubble-wrap (Fig. 6). All visible pieces were retrieved including small pieces only a few inches in length. At 12:21 another small device that emitted a short pulse of smoke was set and detonated at the location of the two previous UNDETs. At 12:26 personnel transfers were begun between the three vessels, after which all vessels departed the range to return to port. Therefore the post-exercise mitigation observations were conducted for approximately 25-30 minutes after event two. During the return transit, a green sea turtle (*Chelonia mydas*) was observed at 12:34 (bearing 100 degrees to starboard, distance 10 m). The approximate distance of this sighting to the UNDET location was 3,058 m (3345 yds), well outside of mitigation range. The monitoring vessel returned to port at 12:42, for a total on-water time of two hours 46 minutes.

Figure 3. MDSU-1 divers preparing for the UNDET. RHIB is visible at right. Divers from the crew of the RHIB in the foreground right place charges at the obstruction marked by the buoy at far left. The second RHIB in the background conducts a circular perimeter.

Figure 4. Event two of 26 April: 2.44 lb.

Figure 5. Sheared metal of the simulated obstruction after exercises of 26 April.

Figure 6. MDSU-1 retrieving plastic bubble-wrap pieces from water surface following UNDETs of 26 April.

3.2.2 UNDETs of 27 April

As during the previous day, the purpose of the exercise was harbor clearance, training with the same simulated obstruction and clearance techniques as described above. As before, the monitoring vessel was one of three vessels at the training location, the other two being ~24 ft RHIBs operated by MDSU-1. Two underwater explosive events were monitored on this day. Both UNDET locations on this day were within the Pu'uloa Underwater Range at approximately 21.29025º N, 157.98958º W (**Error! Reference source not found.**.

EVENT ONE (NEW 6.038 lb): The sea state remained between Beaufort 2-3 throughout the day's effort, with a swell height up to 3 ft . Visibility was excellent throughout the exercise, with no significant cloud cover. The monitoring vessel departed the dock within Pearl Harbor at 09:46, and arrived at the boundary of the range at 10:27. Three green sea turtles were sighted from the time the vessels left the dock to the time that they arrived at the range. Two of these three turtles were mating approximately 20m from shore within Pearl Harbor (Fig. 9). Upon arrival, the crews of the two RHIBs alternated between preparing for the detonation at the UNDET site, and conducting a perimeter visual survey at a radius of between approximately 200 to 350 yds (~180 – 320 m), while the monitoring vessel continually monitored the perimeter at approximately the opposite side of the UNDET location. The two monitoring vessels conducted the visual search to both starboard and port sides to cover the full mitigation range of 700m. The detonation method was the same radio-controlled method of the previous day's exercises. The detonation for event one occurred at 11:01 (Figs. 10, 11). The pre-exercise survey was 34 minutes. The post exercise survey began immediately after event one at 11:03. At 11:07, a green sea turtle was sighted approximately 10 meters from the whaler, and re-sighted at 11:08, 11:10 and 11:11 (Fig. 12). Another green sea turtle was sighted approximately 200 m from the whaler at 11:09. Another green sea turtle was sighted at 11:41, 50 meters from the whaler, but was outside the exclusion zone. The post-exercise survey was served by the pre-exercise survey for event two, and began at 11:11 and lasted for 39 minutes, which was 30 minutes from the last sighting at 11:11 within the exclusion zone.

EVENT TWO (NEW 16.106 lb): The 30 minute monitoring interval for event two began at 11:11 (i.e., after the last sea turtle sighting within the mitigation zone) again with the RHIBs alternating between monitoring and preparing the charge for radio-controlled detonation. This second detonation, of 16.016 lb net explosive weight, occurred at 11:50 (Fig. 13), for a total of 39 minutes of pre-exercise survey. No green sea turtles were sighted between 11:50 and 12:18. Visual monitoring continued, and at 12:18, a small charge producing a short burst of smoke was activated at the UNDET location as in the previous day. At this time, preparations began to leave the exercise site. The monitoring vessel departed the previously-surveyed perimeter at 12:24, for a total post-exercise survey of 34 minutes. One dead fish – likely a filefish or triggerfish – was sighted after event two (Fig. 14). An attempt was made to collect the fish for identification, but collection was not possible without a net. The monitoring vessel went off-effort at 12:34, outside the Pearl Harbor entrance channel approximately west of the Honolulu airport's reef runway. Two mating green sea turtles were sighted off-effort near the entrance channel. Total monitoring time was 2 hours 48 minutes.

Figure 7. UNDET monitoring of 27 April 2011. The boundaries of the Pu'uloa Underwater range are marked by the yellow square. Monitoring vessel track shown in pink. The entrance to Pearl Harbor is at top. Sightings key: CM=Chelonia mydas.

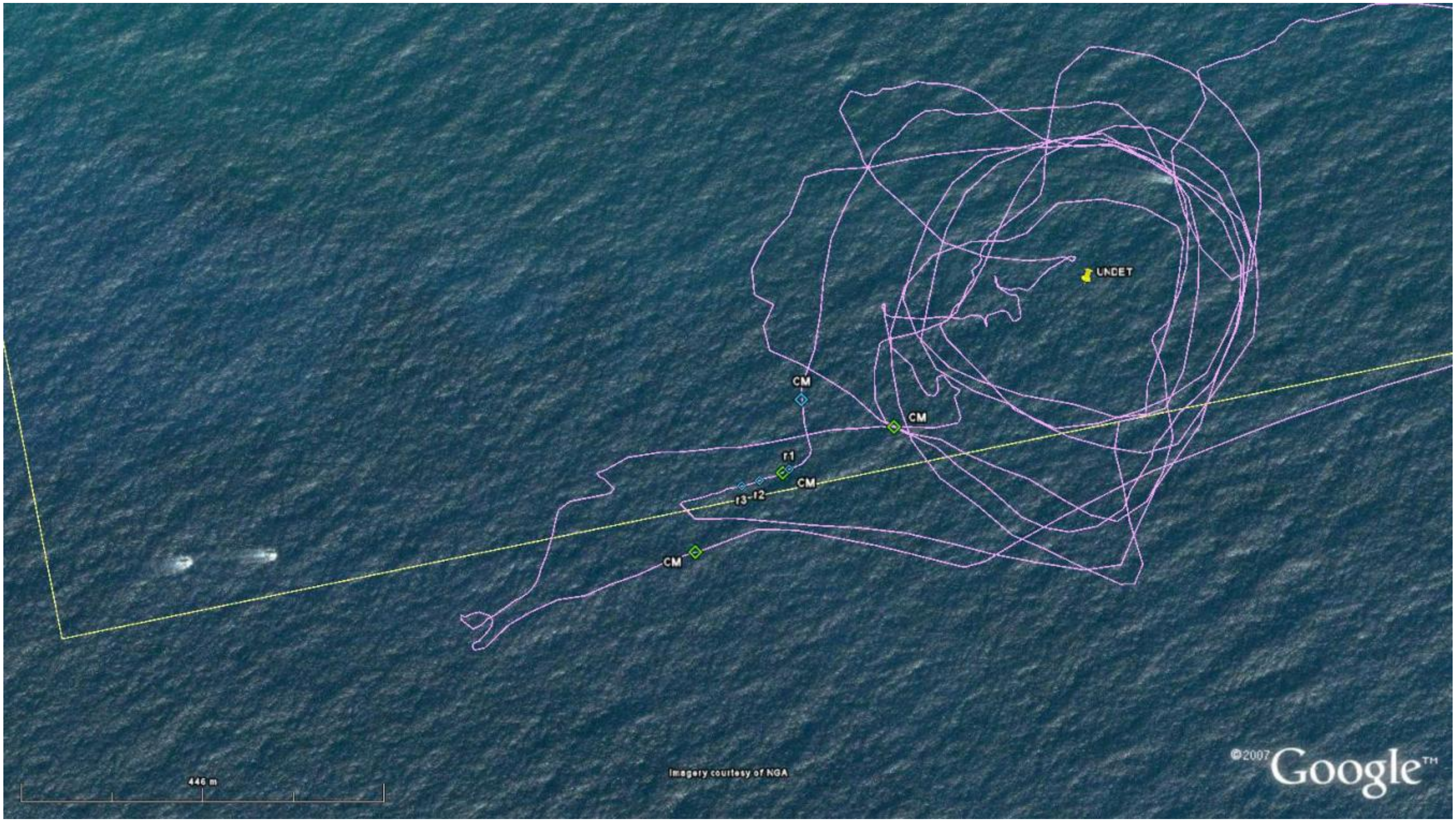

Figure 8. Detail of UNDET monitoring of 27 April 2011. The boundaries of the Pu'uloa Underwater range are marked by the yellow lines. Monitoring vessel track shown in pink. Sightings key: CM=Chelonia mydas; r1/r2/r3=successive re-sights of the CM in blue.

Figure 9. Green sea turtles mating in Pearl Harbor.

Figure 10. Event one of 27 April: 6.038 lb shot.

Figure 11. Water surface immediately after Event one of 27 April: 6.038 lb shot.

Figure 12. Green sea turtle sighted 11:07, April 27 after event one.

Figure 13. Event two of 27 April: 16.106 lb shot.

Figure 14. Dead filefish or triggerfish after event two of 27 April.

4. CONCLUSIONS

4.1 MARINE MAMMAL MONITORING

MDSU-1 was cooperative and instrumental with the coordination of placing MMOs on board for monitoring the UNDET events. In general, the UNDET training requires Navy divers to be vigilant with a number of safety considerations, not only for the environment, but for the personnel on board and civilians in the vicinity. Overall they knew the mitigation requirements well and followed them as described in the MMPA permit and Hawaii Range Complex EIS. The MMO time spent with the Navy divers helps foster the understanding of why these mitigation measures are in place and how important these measures are to protecting marine life and also to Navy training. Protocols for the coordination of future UNDET monitoring efforts were also clarified.

5. ACKNOWLEDGEMENTS

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APPENDIX J. Movements and Spatial Use of Satellite-tagged Odontocetes in the Western Main Hawaiian Islands: Results of Fieldwork Undertaken off O'ahu in October 2010 and Kaua'i in February 2011

Movements and spatial use of satellite-tagged odontocetes in the western main Hawaiian Islands: results of field work undertaken off O'ahu in October 2010 and Kaua'i in February 2011

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SUMMARY

Although considerable information is available on residency patterns and spatial use of odontocetes in the eastern half of the Hawai'i Range Complex (HRC), much less is known about odontocetes in the western half of the HRC. In the first year of a three-year effort we undertook surveys off O'ahu (in October 2010) and Kaua'i (in February 2011) to examine spatial use and residency patterns using satellite tags, as well as obtaining individual identification photographs and biopsy samples for assessment of population identity and structure. In 18 days of combined effort we encountered 43 groups of 10 species of odontocetes, deployed 15 satellite tags on three species, obtained over 23,000 photographs for contribution to photo-identification catalogs, and obtained 39 genetic samples of six species. Location data were obtained from satellite tags for periods from 7.2 to 223 days (median = 36.8 days). Tags deployed on three Hawaiian insular false killer whales provided the most detailed dive data yet available for this species and movement data will be contributed to studies of critical habitat for this species. Satellite tags were deployed on individuals in two groups of pygmy killer whales, one of the least known species of delphinids world-wide and a rare species in Hawaiian waters. Habitat use of the two groups differed substantially, and may be related to the residency of the groups as evident from photo-identification data. Most individuals in one group had been previously photo-identified off O'ahu (12 of 15), some in up to three previous years, and the group spent the 30 days post-tagging along the south and west shores of O'ahu and off the western end of Penguin Bank, remaining primarily in water depths of less than 1,000 m (median depth = 576 m). Although 17 individuals in the other group were photo-identified, none had not been previously photographed off O'ahu, although one had been previously documented off each of Lana'i and Hawai'i. The tagged individual from this group moved repeatedly from less than 1,000 m depth to over 3,000 m depth off O'ahu, spending most of its time over the 7 days of tracking in water depths greater than 1,000 m (median depth = 2,487 m). Short-finned pilot whales were tagged both off O'ahu (six individuals) and Kaua'i (three individuals). As with the pygmy killer whales, considerable variation in movement patterns and habitat use were apparent with tagged short-finned pilot whales, with some groups remaining close to the area of tagging, suggesting residency, and others moving over very wide ranges and using a broad range in depths, illustrating different ranging patterns that may have implications for exposure and responses to Navy exercises. Combined these studies provide the most detailed information yet available on spatial use and ranging patterns of both pygmy killer whales and short-finned pilot whales in the western half of the HRC.

INTRODUCTION

Considerable information is available on residency patterns and spatial use of a number of species of odontocetes in the eastern half of the Hawai'i Range Complex (HRC), particularly off the island of Hawai'i (e.g., Aschettino et al. in press; Baird et al. 2008a, 2008b, 2009, 2010, 2011; McSweeney et al. 2007, 2009; Schorr et al. 2009). Favorable working conditions have resulted in a concentration of research activities off the island, where the presence of very deep water (>2,000 m) close to shore has facilitated research with a number of typically deep-water species, as well as with shallow-water species. One of the main findings of this work is that there are resident populations of more than half of the species of odontocetes found off the island of Hawai'i, including short-finned pilot whales, pygmy killer whales, melon-headed whales, common bottlenose dolphins, rough-toothed dolphins, Blainville's beaked whales, Cuvier's beaked whales, and dwarf sperm whales (e.g., Aschettino et al. in press; Baird et al. 2008a, 2008b, 2009, 2010, 2011;

McSweeney et al. 2007, 2009; Schorr et al. 2009). In addition to these resident populations, individuals of some species are known to regularly move among the islands (e.g., false killer whales), and at least one has two populations that use the area (melon-headed whales, which have both a resident population to the island of Hawai'i and a population that moves among all of the main Hawaiian Islands and into offshore waters; Aschettino et al. in press, Woodworth et al. in press).

Less is known about residency and spatial use of odontocetes in the western half of the HRC. The smaller size of the islands (Kaua'i, Ni'ihau, O'ahu) result in smaller lee areas and thus less ideal working conditions, and the shallower slopes to the islands mean that deep water is further offshore and thus in less protected areas. Most of the research that has been done has focused on photo-identification and biopsy sampling (e.g., Baird et al. 2003, 2006, but see Baird et al. 2008c), and has identified the existence of some island-specific populations of more commonly-encountered species, like rough-toothed dolphins off Kaua'i/Ni'ihau (Baird et al. 2008a) and bottlenose dolphins off both Kaua'i/Ni'ihau and O'ahu (e.g., Baird et al. 2009; Martien et al. in press), but less is known about less-frequently encountered and/or deeper-water species. Navy exercises frequently occur in the western half of the HRC, thus there is a need for additional information on residency patterns and spatial use of protected species in that area to be able to assess the likelihood of exposure to exercises and interpret potential reactions. One of the primary purposes of this project is to address this information gap. A number of tools are used to accomplish this, in particular deployment of medium-term Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) satellite tags on a number of species of odontocetes. Importantly, photo-identification data is also used to interpret spatial use patterns, building on long-term photo-identification catalogs compiled from throughout the main Hawaiian Islands, and collection of genetic samples to contribute to studies of population structure. This report summarizes results from the first year of this effort, with field activities undertaken in two periods: October 2010 off the island of O'ahu, and February 2011 off the island of Kaua'i. In addition to support from N45 and the Naval Postgraduate School, these field efforts were supported in part by funding from the Pacific Islands Fisheries Science Center and by Commander, Pacific Fleet.

METHODS

Surveys were undertaken off the island of O'ahu for 14 days in October 2010, based out of Ko'olina Marina, using a 27' Boston Whaler outfitted with a tower and bow pulpit. Efforts were made to cover as broad a range off the southern and southwestern shores of the island as possible, with efforts concentrated away from shallow (e.g., <200 m) nearshore areas, as weather conditions permitted. Observers scanned 360 degrees around the research vessel, which transited typically at speeds of 15-30 km h^{-1}. Surveys off the island of Kaua'i were undertaken for 4 days in February 2011 as part of a survey coordinated by NAVFAC Pacific. During the Kaua'i effort groups were located by three observers on-board the 96' R/V Searcher, and tagging operations were undertaken from a 15' rigid-hulled inflatable. During both field operations efforts were made to obtain photographs of all individuals in groups of odontocetes encountered and biopsy samples of most species.

Two types of satellite tags were used: a small location-only SPOT5 tag (Wildlife Computers, Inc., Redmond, WA), or a Mk10-A SPLASH tag that recorded both information on location and diving behavior, both in the LIMPET configuration (Andrews et al. 2009; Schorr et al. 2009; Baird et al.

2010). Attachment darts penetrated 4.5 cm into the dorsal fin for small species (e.g., pygmy killer whales) or 7 cm into the dorsal fin for larger species (e.g., false killer whales, short-finned pilot whales). Tags were programmed to transmit for variable periods during the day corresponding to the periods with the best satellite overpasses.

Data obtained from the Argos system was processed with the Douglas Argos-Filter v. 7.08 (available at Alaska.usgs.gov/science/biology/spatial/douglas.html) using two independent methods: distance between consecutive locations, and rate and bearings among consecutive movement vectors. Each location is assigned a "location class" by Argos, which reflects the estimated precision of the location, with the most precise locations being classes 3 and 2. We set the Douglas Argos-Filter to automatically retain location classes 3 and 2. Maximum rate of movement was set at 10 km h-1 for pygmy killer whales and 15 km h-1 for short-finned pilot whales and false killer whales. Depth and distance from shore for all locations which passed the Douglas Argos-filter were determined in ArcGIS v. 9.2 (ESRI, Redlands, California) using a 50 m x 50 m multibeam synthesis bathymetry model from the Hawaiʻi Mapping Research Group (available at www.soest.hawaii.edu/HMRG/multibeam/index.php).

To determine whether individuals with overlapping tag data were acting in concert or independently, we calculated the straight-line distance (i.e., not taking into account potentially intervening land masses) between pairs of individuals when locations were obtained during a single satellite overpass. We used both the average distances between pairs of individuals and the maximum distance between pairs to assess whether individuals were acting independently.

Photographs of tagged and companion whales were added and compared to individual photo-identification catalogs for each species maintained by Cascadia Research Collective (e.g., Baird et al. 2008b; McSweeney et al. 2009). Previous sighting history of individuals within groups were examined to assess whether individuals were part of resident populations from the areas they were tagged or potentially part of offshore populations or individuals moving from other islands.

RESULTS AND DISCUSSION

In field efforts off Oʻahu in October 2010 we encountered 30 different groups of 10 different species of odontocetes, were able to collect 32 genetic samples (from six species) for studies of population structure, and took over 18,000 photographs for individual identification and for species identification (Table 1). During the Kauaʻi effort there were 13 encounters with four different species of odontocetes, we were able to collect seven genetic samples from two species, and took over 5,500 photographs (Table 2). During the two field operations satellite tags were deployed on 15 individuals of three different species of odontocetes (Table 3). Three tags were deployed on false killer whales from the Hawaiʻi insular population, including the first deployments of combination location/dive tags on this species. Although detailed analyses from the false killer whale tag deployments will be reported elsewhere (Baird et al. in prep), there are several points that warrant mentioning. These deployments were the second set of satellite tag deployments on false killer whales off the island of Oʻahu (the first were deployed in October 2009; see Baird et al. 2010), and greatly increase our understanding of movements of individuals from this population in the western half of the Hawaiʻi Range Complex. One of the individuals tagged (HIPc272) had been previously tagged off the island of Hawaiʻi (see Baird et al. 2010). A comparison of spatial use of this individual during the two different years illustrates differences in spatial use among years for this species (Figure 1). When tagged in 2008, HIPc272 spent the majority of its time on the leeward sides of the islands and moved from Hawaiʻi Island to Oʻahu, whereas in 2010 this individual restricted its movements to the area from Oʻahu to Maui, despite the fact that the tracking period was longer in 2010 (32 days) than in 2008 (26 days), and made extensive use of both the windward and leeward sides of the islands. Such an example of differences in movements of the same individual tagged in two different locations (in two different years) demonstrates that movements of individual false killer whales may be influenced by the location of where they were tagged and/or vary between years.

Three tags were deployed on pygmy killer whales off Oʻahu, in two different groups. These tag deployments represent the first movement data available for this species away from the island of Hawaiʻi, and a substantial increase in what is known about spatial use of this species, both in Hawaiʻi and world-wide. Two of the individuals were tagged in the same group, although the tags were deployed five days apart. When this group was first encountered identification photos were obtained from 15 distinctive individuals, 12 of which (80%) had been previously documented off the island of Oʻahu in from two to four different years (Table 4). Both of the tagged whales had been previously photographed off Oʻahu together in October 2008 and August 2009, and both were photographed together in December 2010 after the tags had come off. Three other individuals present in the group had also been previously photo-identified off Oʻahu in 2007, 2008 and 2009 (the latter two years with the two whales who were tagged also present), all suggesting this group is resident to the island. Satellite data from the two individuals combined were available for 30 days post-tagging. The group moved from the southwest coast of Oʻahu to off the south coast, and then spent the majority of their time in a small area off the western edge of Penguin Bank (Figure 2). The group was documented almost entirely in depths of less than 1,000 m (median depth of location = 576 m; Figure 3). Identification photos were available from 17 distinctive individuals from the second group tagged, and two of those individuals (11.8%) had been previously documented, one off the island of Hawaiʻi and one off Lanaʻi (Table 4). The movement of one individual from Hawaiʻi to Oʻahu represents the first inter-island movement documented from photo-identification data for this species. Prior to this effort movement data were available from just two pygmy killer whales tagged off the island of Hawaiʻi. Both individuals were part of the same social group although they were tagged four months apart, and both individuals remained strongly associated with the island (Baird et al. 2011). The overall low re-sighting rate and lack of previous records from Oʻahu suggest the second group we tagged is not resident to the island. Satellite data from this group over a 7 day period showed a very different pattern than the first group tagged, with repeated movements from less than 1,000 m depth to over 3,000 m depth (Figure 2). Overall this group used a much broader range of water depths (Figure 3) with a median depth of 2,487 m. Combined the results suggest that habitat use may depend strongly on the whether the area is a core area for the group (e.g., Oʻahu/Penguin Bank for FaTag5 and FaTag6) versus an area visited only rarely (FaTag7).

Nine satellite tags were deployed on short-finned pilot whales, with six deployments (on three different days) off Oʻahu and three (on two different days) off Kauaʻi. An analysis of distance among tagged individuals that were either tagged on the same day or tagged on subsequent days but for which some individuals were in common between the two groups suggest that seven different social units were tagged (Table 5). Of the groups where tags were deployed, the proportion of individuals that had previously been photographically documented ranged from 0 to 94% (Table 4). Almost half of the distinctive individuals (9 of 21) in the first group of pilot whales tagged off Oʻahu had been previously photo-identified off the island of Lanaʻi (Table 4).

Individuals from this group remained strongly associated with Oʻahu and the 4-island area (the islands of Molokaʻi, Maui, Lanai and Kahoʻolawe) for the entire duration of tag transmissions (Figure 4), covering a 223 day span for one individual (GmTag43). Most of the time was spent off the leeward (west) shores of Lanaʻi and the south and west shores of Oʻahu, with relatively little time spent on the north side of Oʻahu or north of the 4-island area (Figure 4). Tagged individuals from this group were strongly associated with the slope, with most locations in depths of less than 3,000 m (Figure 5; GmTag41 median = 1,364 m, GmTag42 median = 1,514 m, GmTag43 median =1,488 m). Maximum distance moved from the tagging location for these individuals was 153 km. The relative lack of movements, strong association with the slope, and large proportion of individuals that had been previously photo-identified suggest this is a resident group to the Oʻahu/4-islands area.

By contrast, the three individuals tagged off Oʻahu on 19 October 2010 ranged widely both among the western main Hawaiian Islands almost as far as Nihoa in the northwestern Hawaiian Islands and offshore (Figure 6). While remaining within the HRC, one individual (GmTag44) crossed three management boundaries; the long-line exclusion zone around the main Hawaiian Islands, the Papahānaumokuākea Marine National Monument Boundary, and the U.S. Exclusive Economic Zone boundary surrounding Hawaiʻi (Figure 6). This is the first direct evidence that any species of odontocetes from the main Hawaiian Islands may utilize either waters within the Marine National Monument or international waters. A comparison of distances among these individuals indicated that the three individuals were likely from two different social units, with GmTag44 and GmTag45 remaining relatively close together (median = 2.4 km) for the nine days of overlap (Table 5). Although tagged only a couple of kilometers apart, GmTag44 and GmTag46 separated by 457 km (median distance apart = 164.1 km). Depths used by these individuals were almost entirely greater than 3,000 m (GmTag44 median = 4,616 m; GmTag46 median = 4,331 m; Figure 5).

Three pilot whales were satellite tagged off the north side of Kauaʻi on two consecutive days in February 2011. Two of the three individuals were tagged on the same day although in different sub-groups. Photo-identification data revealed that one sub-group had no previous sightings (0 of 15 individuals; Table 4), while the other had 16 of 17 individuals previously documented, off the island of Oʻahu (Table 4). Comparison of distances among individuals over the period of tag overlap also suggested that these individuals were from different social units, with median distance apart of almost 20 km (Table 5, maximum distance apart = 199.6 km). Although analyses of depth use are not yet available for the individuals tagged off Kauaʻi, overall ranging patterns did differ between the three individuals (Figure 7), with one moving to Oʻahu and back, and another moving further west.

Results from this work represent a dramatic increase in what is known about spatial use and residency patterns of both short-finned pilot whales and pygmy killer whales in the main Hawaiian Islands, in particular in the western half of the HRC. The tags deployed on short-finned pilot whales off Oʻahu that broadly utilized offshore waters provide evidence that individuals of this species in Hawaiʻi may have alternative spatial use strategies, with some remaining in restricted areas and primarily using slope habitats, and others roaming widely and using open-ocean habitats (Figure 4, Figure 6). Such results have implications for both the potential of exposure of groups to mid-frequency sonar from Navy exercises, and for their potential responses to exposure. Future additional incorporation of photographs of pilot whales from Kauaʻi and Oʻahu, and additional tag deployments, will allow for a more thorough understanding of the spatial use and residency patterns of this species in the western HRC, and assessment of responses of instrumented individuals to exercises.

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Table 1. Details of odontocete sightings off O'ahu in October 2010.

Species	Date	Sighting #	Group size (best)	# genetic samples	# photos
Blainville's beaked whale	19-Oct-10	5	3	0	274
Blainville's beaked whale	20-Oct-10	2	4	0	55
Bottlenose dolphin	14-Oct-10	1	19	2	258
Dwarf sperm whale	20-Oct-10	3	1	0	0
False killer whale	15-Oct-10	2	28	3	2,030
False killer whale	22-Oct-10	2	19	1	1,437
Melon headed whale	18-Oct-10	2	1	0	2
Pantropical spotted dolphin	10-Oct-10	1	80	2	398
Pantropical spotted dolphin	10-Oct-10	4	45	0	113
Pantropical spotted dolphin	13-Oct-10	1	11	2	98
Pantropical spotted dolphin	13-Oct-10	2	65	1	37
Pantropical spotted dolphin	14-Oct-10	2	50	0	32
Pantropical spotted dolphin	18-Oct-10	3	85	2	173
Pantropical spotted dolphin	19-Oct-10	1	75	0	7
Pantropical spotted dolphin	19-Oct-10	2	40	0	18
Pantropical spotted dolphin	20-Oct-10	1	40	1	75
Pantropical spotted dolphin	21-Oct-10	1	120	2	166
Pantropical spotted dolphin	23-Oct-10	1	170	0	771
Pygmy killer whale	13-Oct-10	3	18	0	1,820
Pygmy killer whale	18-Oct-10	1	17	3	1,042
Pygmy killer whale	24-Oct-10	1	25	0	1,676
Rough-toothed dolphin	10-Oct-10	2	14	2	918
Rough-toothed dolphin	10-Oct-10	3	16	2	672
Rough-toothed dolphin	11-Oct-10	1	24	4	891
Short-finned pilot whale	15-Oct-10	1	32	0	2,390
Short-finned pilot whale	16-Oct-10	1	47	2	1,131
Short-finned pilot whale	19-Oct-10	3	56	2	1,207
Short-finned pilot whale	19-Oct-10	4	35	1	668
Spinner dolphin	15-Oct-10	3	25	0	8
Spinner dolphin	22-Oct-10	1	55	0	286

Table 2. Details of odontocetes sightings of odontocetes off Kauaʻi in February 2011.

Species	Date	Sighting #	Group size (best)	# genetic samples	# photos
Bottlenose dolphin	20-Feb-11	1	4	0	80
Bottlenose dolphin	20-Feb-11	2	1	0	34
Rough-toothed dolphin	17-Feb-11	1	2	0	104
Rough-toothed dolphin	17-Feb-11	2	12	2	450
Rough-toothed dolphin	18-Feb-11	2	4	2	139
Rough-toothed dolphin	18-Feb-11	3	5	0	142
Rough-toothed dolphin	18-Feb-11	4	5	1	116
Rough-toothed dolphin	18-Feb-11	5	3	0	52
Rough-toothed dolphin	19-Feb-11	2	18	0	407
Short-finned pilot whale	18-Feb-11	6	17	2	2,807
Short-finned pilot whale	19-Feb-11	1	8	0	46
Short-finned pilot whale	19-Feb-11	3	16	0	594
Spinner dolphin	19-Feb-11	5	55	0	621

Table 3. Information on satellite tag deployments during October 2010 and February 2011.

Species	Tag ID	Date deployed	Island tagged	Individual ID	Duration of signal (days)	Data type [1]
Pygmy killer whale	FaTag5	13 Oct 10	Oʻahu	HIFa368	11.8	L
Pygmy killer whale	FaTag6	18 Oct 10	Oʻahu	HIFa371	25.5	L
Pygmy killer whale	FaTag7	24 Oct 10	Oʻahu	HIFa459	7.2	L
Short-finned pilot whale	GmTag41	15 Oct 10	Oʻahu	HIGm1291	22.8	L
Short-finned pilot whale	GmTag42	16 Oct 10	Oʻahu	HIGm1296	97.5	L
Short-finned pilot whale	GmTag43	16 Oct 10	Oʻahu	HIGm1297	2232	L
Short-finned pilot whale	GmTag44	19 Oct 10	Oʻahu	HIGm1317	58.0	L
Short-finned pilot whale	GmTag45	19 Oct 10	Oʻahu	HIGm1324	9.3	L
Short-finned pilot whale	GmTag46	19 Oct 10	Oʻahu	HIGm1187	53.1	L
Short-finned pilot whale	GmTag49	18 Feb 11	Kauaʻi	HIGm1374	30.9	L
Short-finned pilot whale	GmTag50	18 Feb 11	Kauaʻi	HIGm0180	36.8	L/D
Short-finned pilot whale	GmTag51	19 Feb 11	Kauaʻi	HIGm1400	37.1	L
False killer whale	PcTag26	15 Oct 10	Oʻahu	HIPc200	13.2	L/D
False killer whale	PcTag27	22 Oct 10	Oʻahu	HIPc132	51.3	L
False killer whale	PcTag28	22 Oct 10	Oʻahu	HIPc272	47.6	L/D

[1] L = Location-only; L/D = Location/Depth. [2] This tag last transmitted on 29 May 2011 and is on a once-every-five-day transmission schedule so may still be functioning as of the time of this report.

Table 4. Information on previous sighting histories of pygmy killer whale and short-finned pilot whale groups or sub-groups where individuals were satellite tagged (see Table 3 for details).

	Date first tag deployed	# distinctive individuals photo-IDd	# (%) seen prior to field effort	Island(s) previously documented
FaTag5, 6	13 Oct 10	15	12 (80.0)	O'ahu
FaTag7	24 Oct 10	17	2 (11.8)	Hawai'i, Lana'i
GmTag41, 42, 43	15 Oct 10	21	9 (42.9)	Lana'i
GmTag44, 45	19 Oct 10	23	0 (0.0)	-
GmTag46	19 Oct 10	16	4 (25.0)	Kaua'i
GmTag49	18 Feb 11	15	0 (0.0)	-
GmTag50	18 Feb 11	17	16 (94.1)	O'ahu
GmTag51	19 Feb 11	12	1 (8.3)	O'ahu

Table 5. Distance (in km) among pairs of satellite tagged short-finned pilot whales tagged either on the same day (see Table 3) or on subsequent days when individuals from the first encounter were also present. For each set of whales both the median distance apart (above the diagonal) and the maximum distance apart (below the diagonal) are shown. Individuals with median distances apart of less than 5 km were considered to be part of the same social unit (highlighted in bold).

	GmTag41	GmTag42	GmTag43
GmTag41	-	12.8	11.8
GmTag42	47.4	-	**3.0**
GmTag43	42.9	24.5	-

	GmTag44	GmTag45	GmTag46
GmTag44	-	**2.4**	164.1
GmTag45	33.2	-	9.1
GmTag46	457.6	155.3	-

	GmTag49	GmTag50	GmTag51
GmTag49	-	19.8	43.3
GmTag50	199.6	-	30.5
GmTag51	313.4	197.9	-

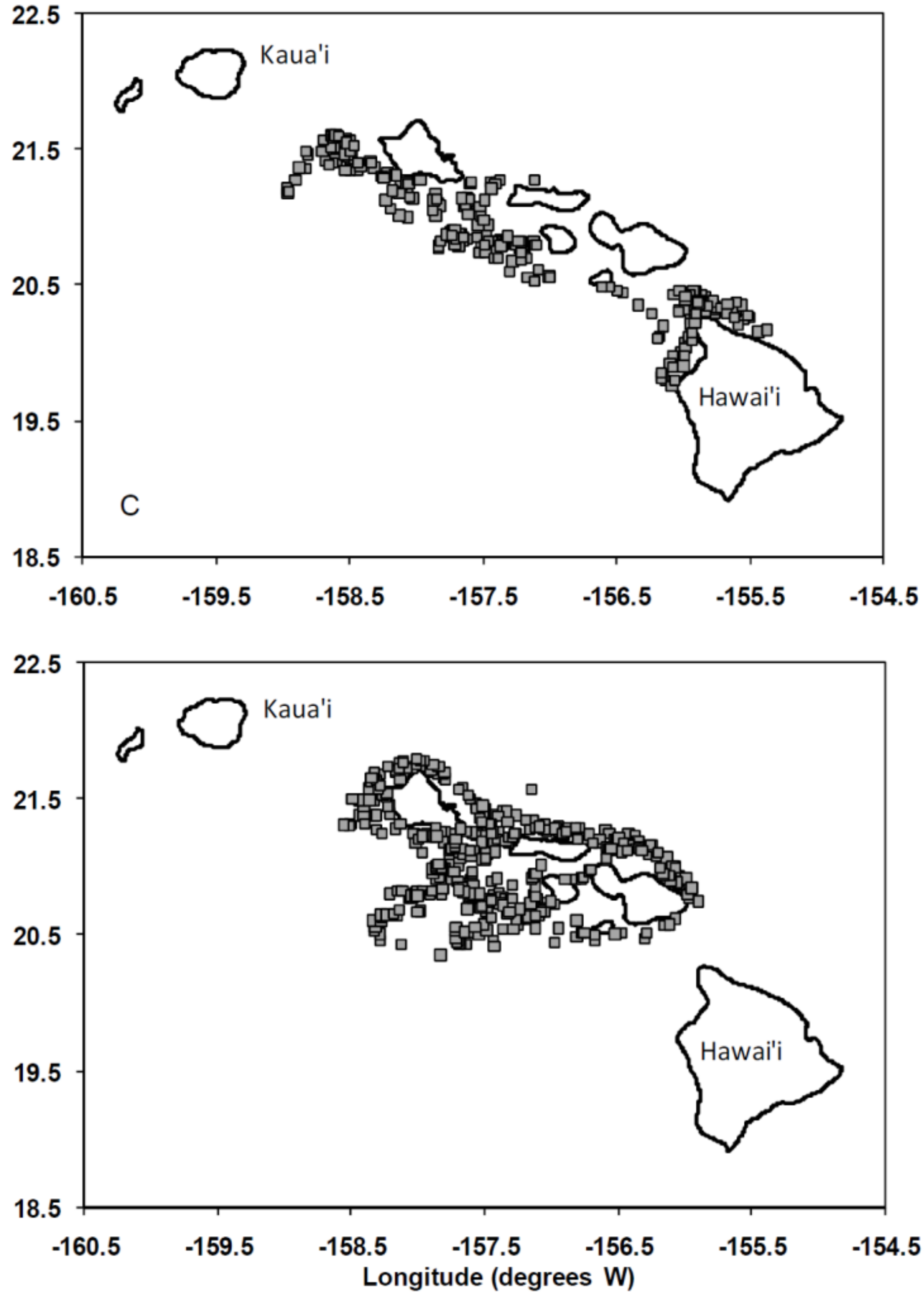

Figure 1. Maps showing spatial use patterns of false killer whale HIPc272 tagged off the island of Hawai'i in 2008 (top, 26 days of movements in September 2008) and off O'ahu in 2010 (bottom, 32 days of movements in October and November 2010).

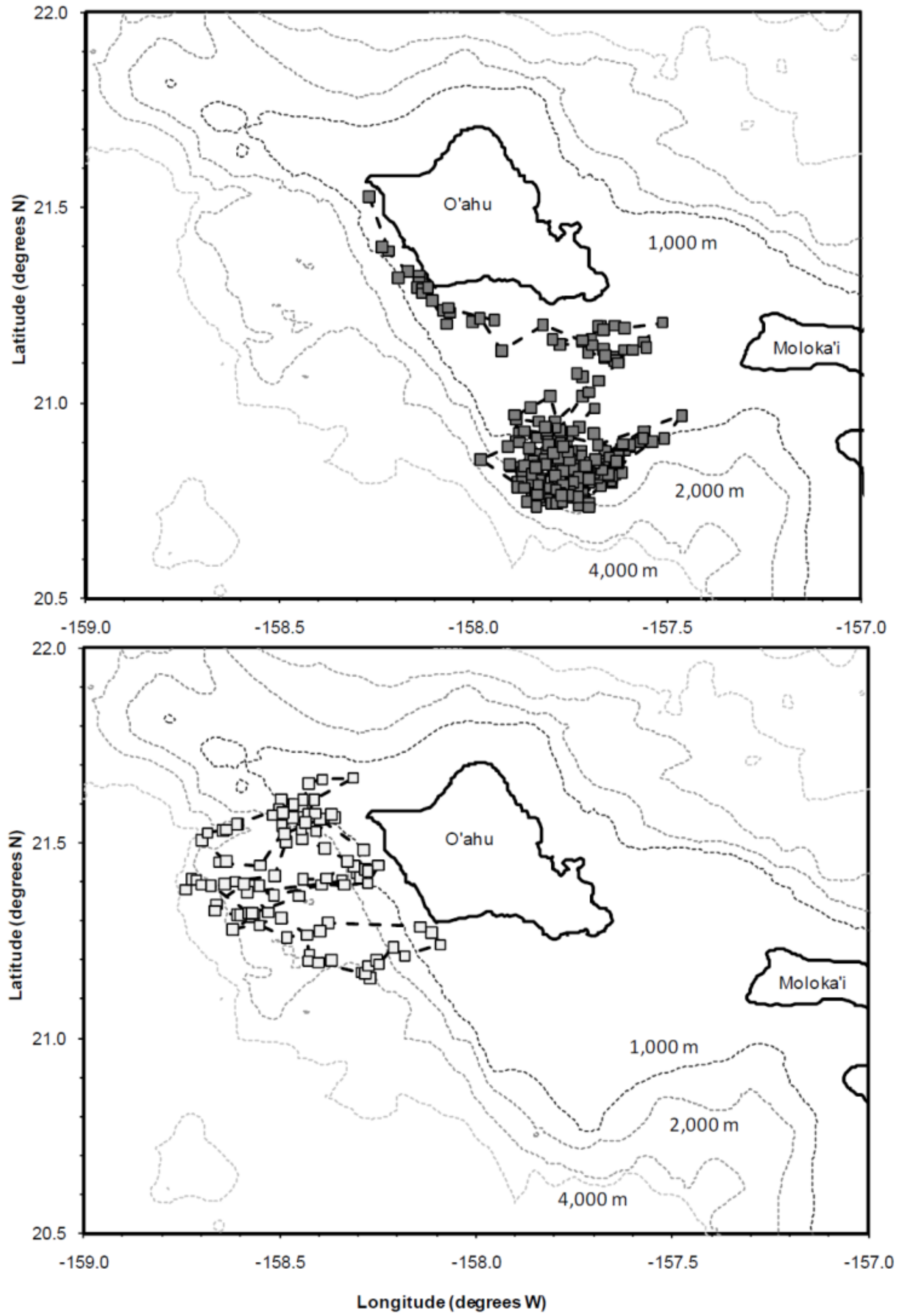

Figure 2 . Locations of satellite-tagged pygmy killer whales tagged off O'ahu in October 2010. Top. Combined track of individuals tagged 13 October 2010 and 18 October 2010, with tot al span of movement data over 30 days. Individuals from this group had been previously documented off O'ahu in 2007, 2008 and 2009. Bottom. Individual tagged 24 October 2010, with movement data over 7.2 days. None of the individuals in this group had been previously documented off O'ahu, although one

individual had been photographed off Hawai'i and one had been recorded off Lana'i. Dotted lines connect consecutive locations but do not necessarily reflect travel routes.

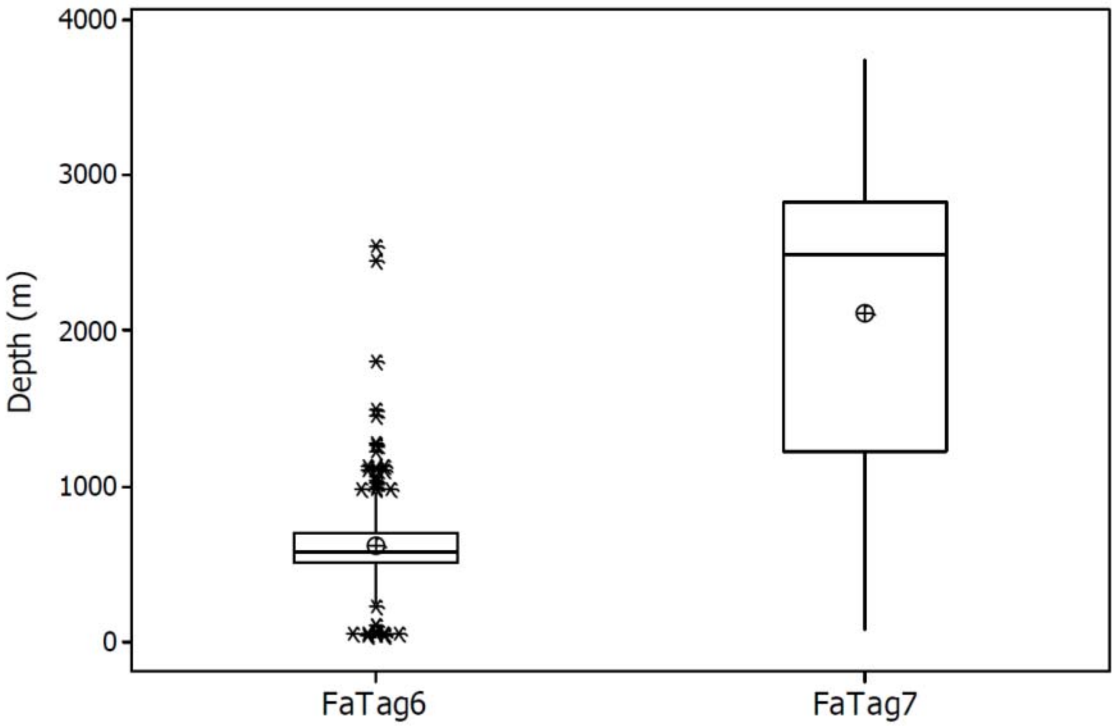

Figure 3. Boxplot showing depth for data from two pygmy killer whales tagged off the island of O'ahu in October 2010. Symbol in middle of box represents mean value; middle horizontal line represents median. The box bottom is at the 25th percentile and the top is at the 75th percentile.

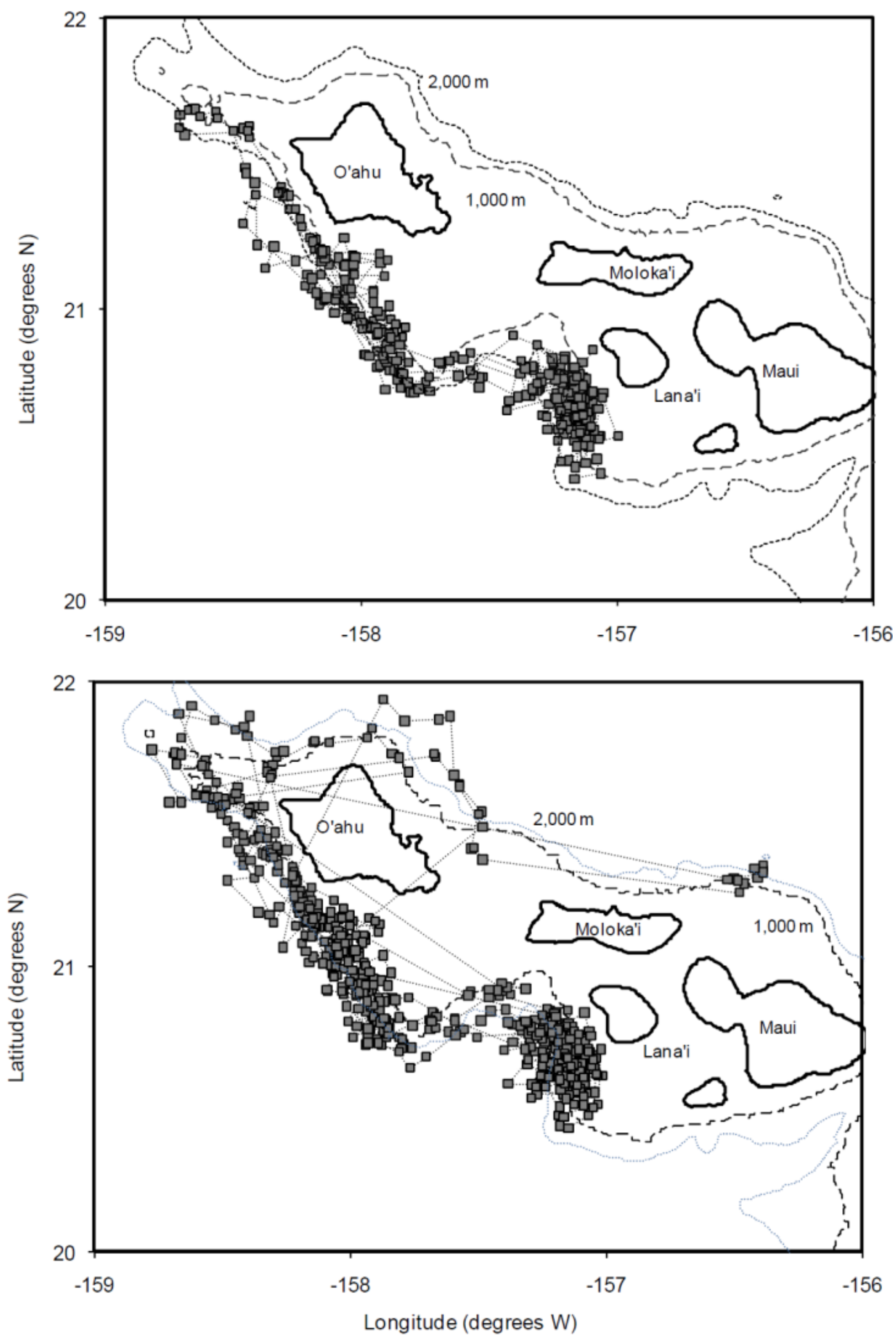

Figure 4. Movements of two short-finned pilot whales tagged off O'ahu on October 16, 2010. Top. GmTag42. Bottom. GmTag43. Dotted lines connect consecutive locations but do not necessarily reflect travel routes.

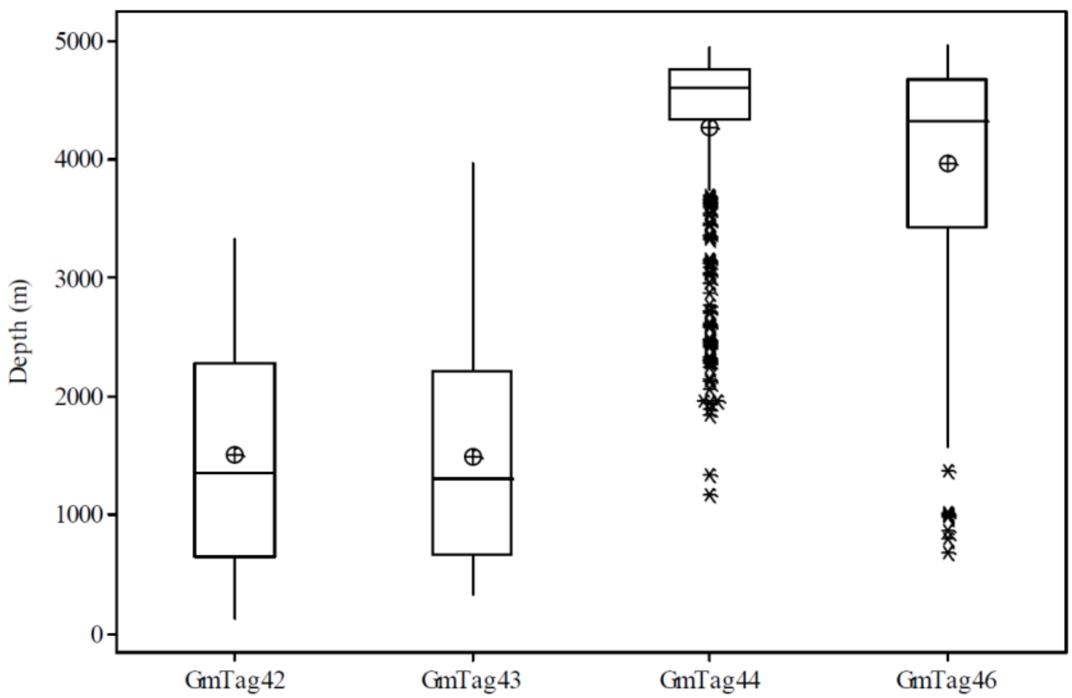

Figure 5. Boxplot showing depth for data from four short-finned pilot whales tagged off the island of O'ahu in October 2010. Individuals GmTag42 and GmTag43 were tagged in the same group October 16, 2010, while GmTag44 and GmTag46 were tagged in two groups separated by 2 kilometers on October 19, 2010. Symbol in middle represents mean value; middle horizontal line represents median. The box bottom is at the 25th percentile and the top is at the 75th percentile.

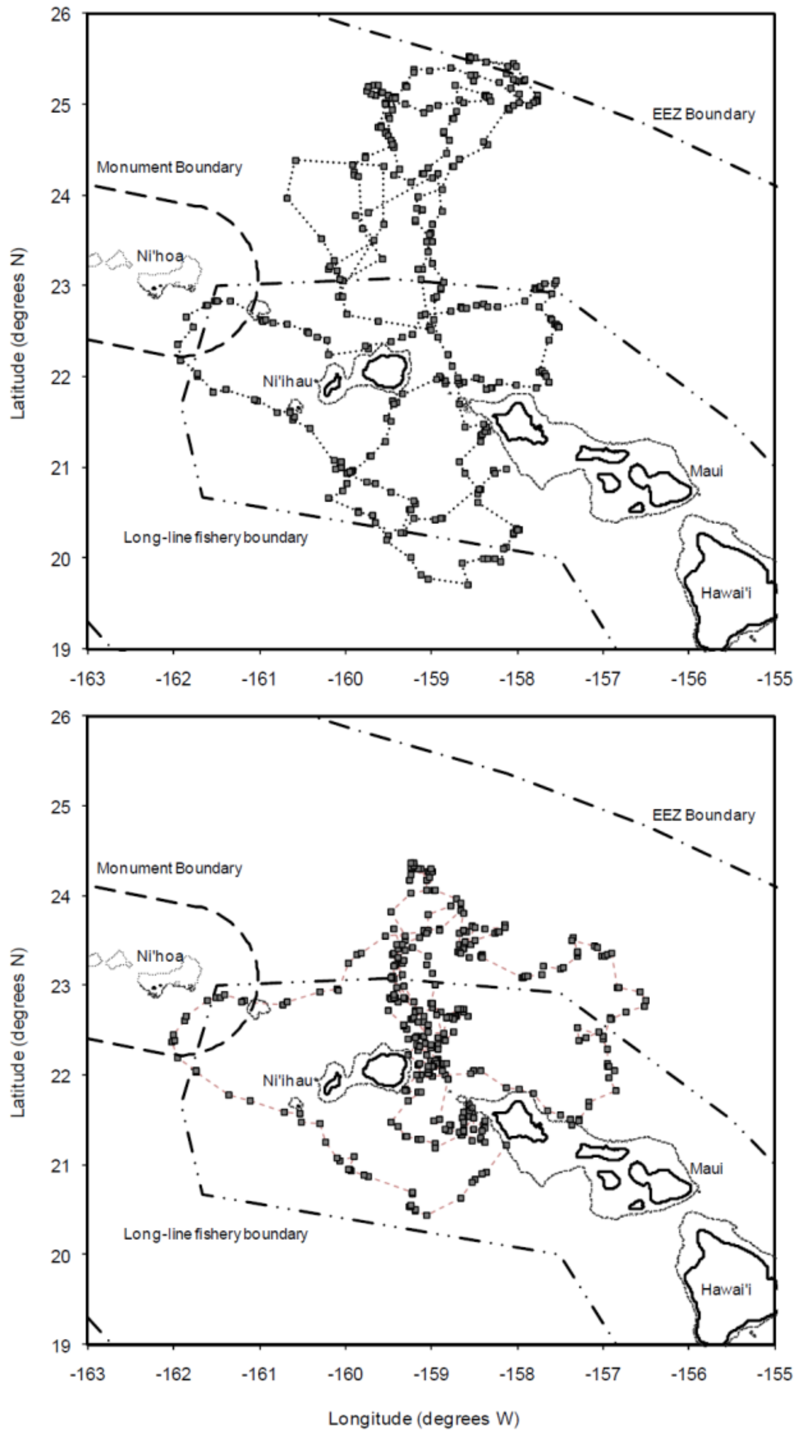

Figure 6. Movements of two short-finned pilot whales tagged (in separate groups) off O'ahu on 19 October 2011. Top. A 58-day track from GmTag44. Bottom. A 53-day track from GmTag46. The 1,000 m depth contour is shown. Dotted lines connect consecutive locations but do not necessarily reflect travel routes.

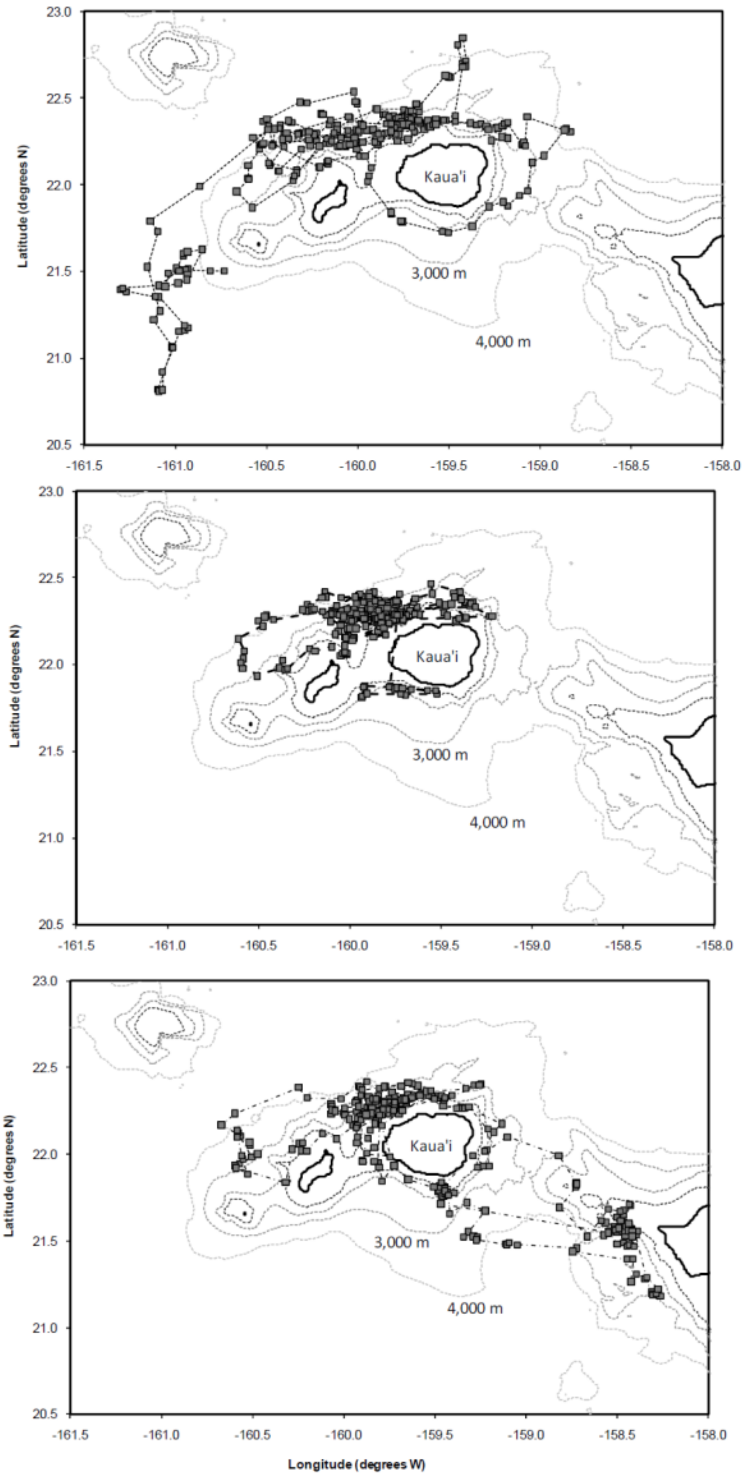

Figure 7. Movements of three satellite-tagged pilot whales tagged off Kaua'i in February 2011. Top. GmTag49, tagged 18 Feb 2011, showing 30.9 days of movements. Middle. GmTag50, tagged 18 Feb 2011, showing 36.8 days of movements. Bottom, GmTag51, tagged 19 Feb 2011, showing 37.1 days of movements. Dotted lines connect consecutive locations but do not necessarily reflect travel routes

APPENDIX K. Analysis of Historical Passive Acoustic Monitoring Recordings in Hawaii Range Complex

This project has been actively in progress since April 2011. Final analyses have not been completed at the time of the writing of the FY11 year-end monitoring report. It is expected that all analyses and the final report will be completed December 2011.

The project's goal is analysis of passive acoustic monitoring recordings that were obtained by scientists at Hawaii Institute of Marine Biology (HIMB) using Ecological Acoustic Recorders (EAR) devices. The information to be extracted from the recordings is on the presence of marine mammals and the nature of the sounds they make. Some of these historical recordings from 2009 and 2010 coincide with Naval training events in the areas around the islands of Oahu and Kauai. In optimal situations, analysis of days of recordings from a few days before, during, and a few days after the training events were available to characterize the baseline environmental acoustic state before and after events as well as any changes that may occur during events.

The project incorporates various data analyses to enable marine mammal call identification in these acoustic recordings. These analyses consist of detecting and classifying calls present according to marine mammal species, and providing summary statistics of the detected calls. Analysis prioritization is: 1) beaked whales; 2) sperm whales; 3) ESA-endangered baleen whales (blue, fin, humpback); 4) other odontocetes and mysticetes.

The final report is also currently in progress. The report is scoped to include:

- Date and time of acoustic detections of marine mammals from PAM device and direction, if possible
- Basic timeline of each recording highlighting significant events in the recording
- Species or at least family identification of detections, if possible
- Description of breadth of repertoire of marine mammal species
- Quantitative and qualitative description of classes of vocalizations by species, including representative spectrograms
- General characterization of noise levels in the environment during acoustic detections
- Signal to noise ratios of acoustic detections
- Classification and characterization of anthropogenic noise detected
- Description of vocalizations detected by date and location
- General sound budget of the recording site – a description of what types of sounds present occupy what portion of the sound spectrum and general patterns in the sound present in the environment over the diurnal cycle
- Rates of detection of species
- Mean rates of vocalization by species
- Quantifiable changes (if any) in vocalizations during anthropogenic noise
- General changes in marine mammal vocalizations over time
- Rough (qualitative) abundance estimates for species.

Tables 1 and 2 lists the dates for which historical recordings are desired. These dates are historical dates of Navy training events; the goal is the analysis of any recordings available a few days before, during, and a few days after the dates in the tables. Figure 1 illustrates the locations of these devices on maps of the islands of Oahu and Kauai

Table 1. Historical recordings for Oahu

Location No.	Dates of Historical Training Events
2 - Mokapu	3-4 October 2009
3 – Makapuu	23 August 2009 2-4 October 2009
4 – Barber's Pt.	9 & 18 February 2010 30-31 March 2010
5 – Kaena Pt.	17-18 November 2009 18 February 2010

Table 2. Historical recordings for Kauai

Location No.	Dates of Historical Training Events
4 - (SW)	16-19 February 2009 5 May 2009
5 - (NW)	16-19 February 2009 27-29 August 2009 13, 18, & 21 September 2009 17-19 February 2010

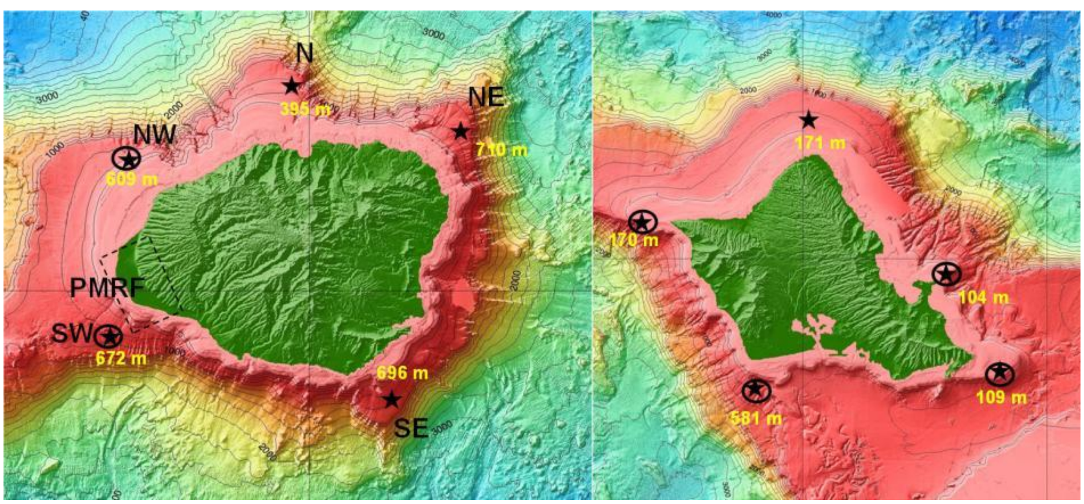

Figure 1. Approximate locations of EARs (shown as stars) deployed around Kauai and Oahu as a part of an ONR program to monitor marine mammals in high Navy activity locations in the Hawaii Range Complex. The circled stars are EARs in which data during specified times were analyzed.

The final report of this project is expected to be included as part of the FY12 year-end monitoring report.

APPENDIX L. Summary Report: Compilation of Total Visual Survey Effort and Sightings for Marine Species Monitoring in Hawaii Range Complex, 2007-2011

August 31, 2011

Prepared for:
Commander, U.S. Pacific Fleet

Prepared by:
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1. INTRODUCTION

In order to train with mid-frequency active sonar (MFAS) and underwater detonations, the Navy obtains incidental take permits and Letters of Authorization from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and Endangered Species Act. The Hawaii Range Complex (HRC) Monitoring Plan was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting are intended to provide science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy exercise activities.

In order to initiate the program of integrating the historical sum of these Navy-sponsored marine species monitoring efforts in the HRC, this summary report describes the efforts to collect, compile, standardize, and migrate existing visually-based field survey data into a fully geo-referenced database in a geographic information system (GIS).

The goal of this initial phase is to process and compile available data from visual surveys performed by both contractor-led efforts as well as Navy in-house ones, such that:

1. A GIS-based summation of all survey tracks could be visualized

2. A geo-referenced database of sightings can be queried to visualize sightings by species or survey variables such as observer platform, sea state, or season

Future goals of later phases include continuing to expand the geo-referenced database with respect to incorporating more past and future survey data, expanding the completing the internal field structure of the geo-referenced database with which more detailed queries will be possible, to compare visual detections with results from past and ongoing passive acoustic monitoring efforts, and to make conclusions as to the effectiveness and interactions of the various variables of visually-based field survey effort in the HRC including: location, platform, field protocol, season, and observational technique (visual or acoustic).

2. METHODS

All visual surveys previously conducted for Commander, U.S. Pacific Fleet's marine species monitoring program were considered for compilation and analysis. Surveys included both those conducted by contractors as well as those conducted by Navy biologists, as well those using both aerial and vessel-based observational methods on both civilian and Navy assets. Not included were surveys and survey legs that did not include collection of a GPS track, or that did not collect positions of sightings, such as nearshore diver-based underwater turtle surveys.

Data collected for each latitude and longitude position of the on-effort survey include date, time, survey description, aerial or vessel platform, seastate, glare, and cloud cover. Data for sightings include species, number of individuals, behavior, and sighting information such as perpendicular angle for aerial surveys, and bearing for vessel surveys. Total distance to the sighting was computed for aerial surveys using altitude and angle, and the same computed for vessel surveys using either direct estimation or sighting device reticle data (e.g., hand-held binoculars or big-eye binoculars). All of the above data fields were standardized to metric units when applicable; a large proportion data deliverables from surveys were not given wholly in metric (e.g., altitude is generally referenced in feet), in which case these were converted in the standardization process such that all data in the resulting georeferenced database were expressed in metric units. Also all data variable types were explicitly specified as text, number, date, or time. Because the data deliverables from the various surveys were sourced from different data collection applications (e.g., WinCruz, Garmin GPS, Excel-based GPS log, manual data entry), all surveys required some translation of the data types, as well as computation for sighting distance. Two examples are illustrated below:

Wincruz Time transformation: For the variable "time," WinCruz raw output tables were extracted from a Microsoft Access database, then the seven or eight character long text string (e.g., "41848") in the field representing time was combined with an associated text string from a separate field representing 12-hour time (e.g., "AM" or "PM") then transformed into 24-hour-formatted time structured as a date field for Microsoft Excel (e.g., 0.679723 = "16:18:48").

Latitude/longitude transformations: Similar transformations were made for latitude and longitude positions such that the numerical values were extracted from text fields, as formatted in various electronic deliverables. For example some inputs were three separate text fields for each position axis, such as " W159 ", "48", and "32" for longitude in degrees, minutes, and seconds, or a single (non-numeric) text field that incorporates both latitude and longitude, such as "N21.35139 W157.94337". Other deliverables were similarly presented in degrees and decimal minutes. All variants were translated into a decimal and entirely numeric representation that incorporates "West" in the case of longitude, e.g., -159.80889.

After standardization, all tracks and sighting data were entered into a single geo-referenced database project using ArcMap 9.3.1 and based within the U.S Navy Environmental Information Management System (EIMS). ArcMap enables queries for specified survey and sighting types, as well as the graphical display on a map of the total sum of sighting and survey track results. Progressive updates or corrections to the source data files immediately results in the ability to generate updated results graphics.

2.1 Included surveys

In total, there were eighteen surveys included in the compilation and analysis, and are listed below with contractor name and contract number:

1. 2007 November 11-17 USWEX aerial survey (MMRC, Contract #N62742-07-P-1914)
2. 2007 November 11-17 USWEX 2007 vessel survey (Cetos, Contract #N62742-07-P-1915)
3. 2008 May 26-27 & June 2-4 USWEX aerial survey (MMRC, Contract #N62742-08-P-1933)
4. 2008 July 12-17 RIMPAC vessel survey 1934 (MMRC, Contract #N62742-08-P-1934)
5. 2008 July 13-17 RIMPAC aerial survey 1935 (MMRC, Contract #N62742-08-P-1935)
6. 2008 August 18-21 SCC aerial survey (MMRC, Contact #N62742-08-P-1942)
7. 2009 February 15-19 SCC aerial survey (SES & MMRC, Contract #N62742-09-P-1956)
8. 2009 June 17-25 ULT and UNDET aerial monitoring (MMRC, Contract #28H-1087365)
9. 2010 February 16-21 SCC aerial survey (MMRC, Contract #N62742-08-P-1803)
10. 2010 June 26-28 Ka'ula islet survey (NAVFAC Pacific)
11. 2010 July 10, 17 RIMPAC SINKEX monitoring, PMRF (NAVFAC Pacific)

12. 2010 August 15-17 RIMPAC vessel survey (HDR, Contract #N62470-10-D-3011 CTO KB01)
13. 2010 November Koa Kai, lookout effectiveness study (NAVFAC Pacific)
14. 2010 November Koa Kai vessel survey (HDR, Contract #N62470-10-D-3011 CTO KB05)
15. 2010 November Koa Kai aerial shoreline survey (HDR, Contract #N62470-10-D-3011 CTO KB05)
16. 2011 February SCC & USWEX lookout effectiveness study (CPF and NAVFAC Pacific)
17. 2011 April 12, May 10, 16 Pearl Harbor entrance channel sea turtle vessel and diver survey (NAVFAC Pacific)
18. 2011 June 30 Ka'ula islet survey (NAVFAC Pacific)

2.1.1 Subset of surveys included for humpback whale analysis

Due to the seasonal presence of humpback whales in the HRC, only surveys spanning from November through April were included for the humpback whale graphic in Fig. 7. Therefore only these surveys tracks are displayed in the graphic of total survey effort below. The surveys included were:

1. 2007 November 11-17 USWEX aerial survey (MMRC, Contract #N62742-07-P-1914)
2. 2007 November 11-17 USWEX 2007 vessel survey (Cetos, Contract #N62742-07-P-1915)
3. 2009 February 15-19 SCC aerial survey (SES & MMRC, Contract #N62742-09-P-1956)
4. 2010 February 16-21 SCC aerial survey (MMRC, Contract #N62742-08-P-1803)
5. 2010 November Koa Kai, lookout effectiveness study (in-house NFP)
6. 2010 November Koa Kai vessel survey (HDR, Contract #N62470-10-D-3011 CTO KB05)
7. 2010 November Koa Kai aerial shoreline survey (HDR, Contract #N62470-10-D-3011 CTO KB05)
8. 2011 February SCC & USWEX lookout effectiveness study (in-house NFP)

2.2 Surveys not included

2.2.1 Surveys with potential to qualify but not included

Other possibly qualifying surveys that were not included, and the reasons these were not included are:

1. 2005 February 17-24 vessel survey (Cetos/Geo-Marine, Contract #2057sa05-F): no electronic deliverables of survey track available.
2. 2006 July 16,17,20,24-6 RIMPAC aerial survey (Kaulakahi & Alenuihaha channels) (MMRC, Contract #N62742-06-P-1887): no electronic deliverables of survey track available.
3. 2007 January 7-February 2 Island of Hawaii vessel survey (Cetos, Contract #N62742s-07-P-1895): no electronic deliverables of survey track available.
4. 2009 August 26-30 SCC aerial survey (MMRC & SES, Contract #N62742-09-P-1966): no electronic deliverables of survey track available.

5. 2011 February 15-20 Ka'ula islet survey (NAVFAC Pacific): data deliverables were not available to be compiled because these have yet to be reconciled between the two vessels utilized during the field effort, one being a contractor-operated vessel, and the other directed by Navy biologists.

If it is intended in FY12 to attempt the resolution of the acquisition of electronic deliverables necessary for incorporation of the items above into the data compilation effort.

See also item #3 in Section 4.2 for surveys not included within the Commander, U.S. Pacific Fleet marine species monitoring program, but which may also qualify for inclusion.

2.2.2 Qualifying survey not included

One qualifying survey was not included at the time of the writing of this report, and will be incorporated into the analysis during FY12:

1. 2010 July 15, 2011 April 26-27 August 10-11 UNDET monitoring, Puuloa range (NAVFAC PACIFIC): The underwater detonation (UNDET) monitoring surveys were graded as lower priority than the other eighteen surveys due to both limited geographic expanse and number of sightings; this item is expected to be incorporated in the next phase of data compilation in FY12.

2.2.3 Partial list of surveys not qualifying

The following surveys were not included in the survey because these did not fulfill the criteria required for compilation into the analysis:

1. 2004-2011 Navy biologist diver underwater surveys for sea turtles (NFESC): no GPS positions of track or sightings
2. 2009 June 18-19 UNDET monitoring (NAVFAC PACIFIC): no GPS positions of track or sightings
3. 2009 July 21-22 Ka'ula islet survey (NAVFAC PACIFIC): no GPS positions of track or sightings

3. RESULTS

3.1 Summary of surveys and sightings

For the analyzed surveys, the following graphics display total survey track effort, and total sightings by species. Species not included due to a lack of sightings occurring within the included surveys are: hawksbill sea turtle (*Eretmochelys imbricata*), sperm whale (*Physeter macrocephalus*), melon-headed whale (*Peponocephala electra*), fin whale (*Balaenoptera physalus*), blue whale (*Balaenoptera musculus*), Longman's beaked whale (*Indopacetus pacificus*), and killer whale (*Orcinus orca*).

Sighting events are denoted by red circles, and may represent one or multiple animals. Special use airspace warning area boundaries are delineated in cyan, and the boundaries of the underwater ranges at PMRF in light green.

The survey tracks for the lookout effectiveness studies conducted on Navy vessels during exercises (survey #13 and #16 in section 2.1) are represented as lines drawn between ship positions filtered to approximately once every several hours so that the general areas traversed by the vessels are well represented, but not the exact track—therefore in some cases sightings from these surveys may appear offset from the indicated track line.

The survey tracks and sightings for some surveys may not be adequately represented at the large scale of the HRC, in particular the diver-RHIB sea turtle surveys conducted outside the mouth of Pearl Harbor (survey #17 in section 2.1). Species where sightings occur very closely together are also similarly not accurately represented on the large HRC-scale map, in particular sea turtles and humpback whales (Figs. 5, 7), due to overlap of sighting markers.

Figures 1-4 show all sightings of marine mammals, with the exception of humpback whales for the sake of clarity because of the high frequency of sighting of this species. Figures 5-20 illustrate sightings by species or species groups.

3.2 Figures

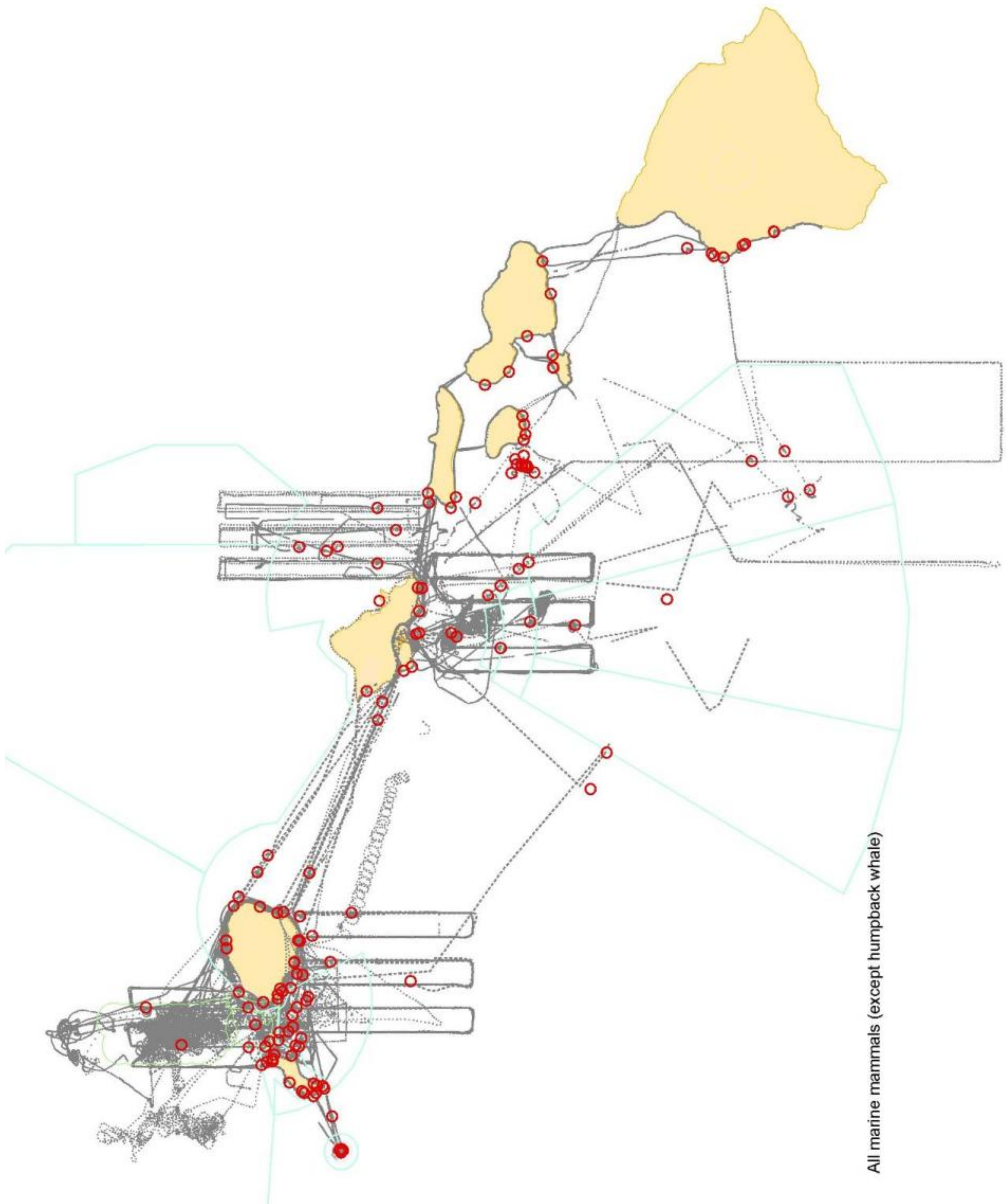

Figure 1. All survey tracks and all marine mammal sightings (except humpback whale)

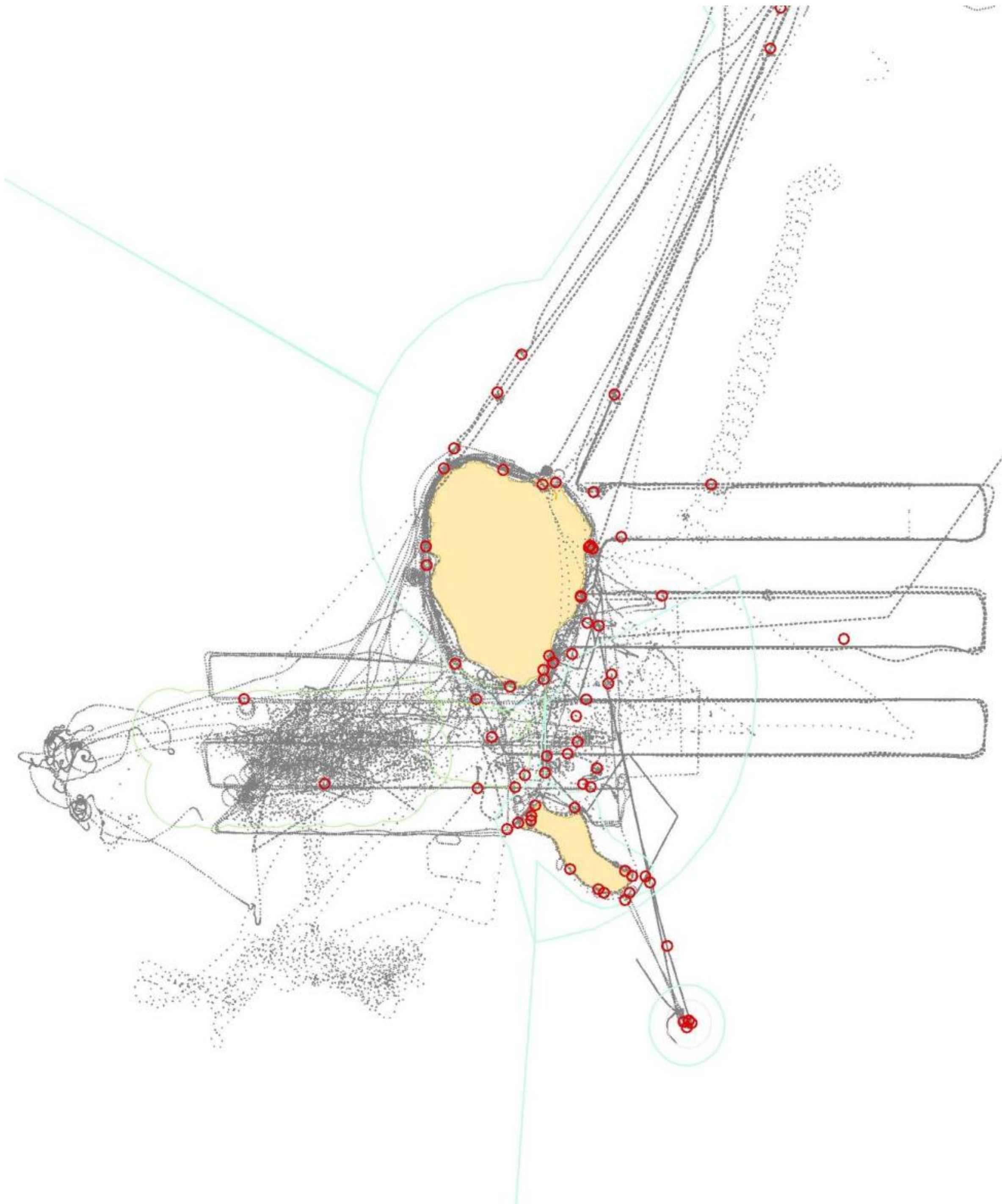

Figure 2. : Detail Kauai/Niihau: All survey tracks and all marine mammal sightings (except humpback whale)

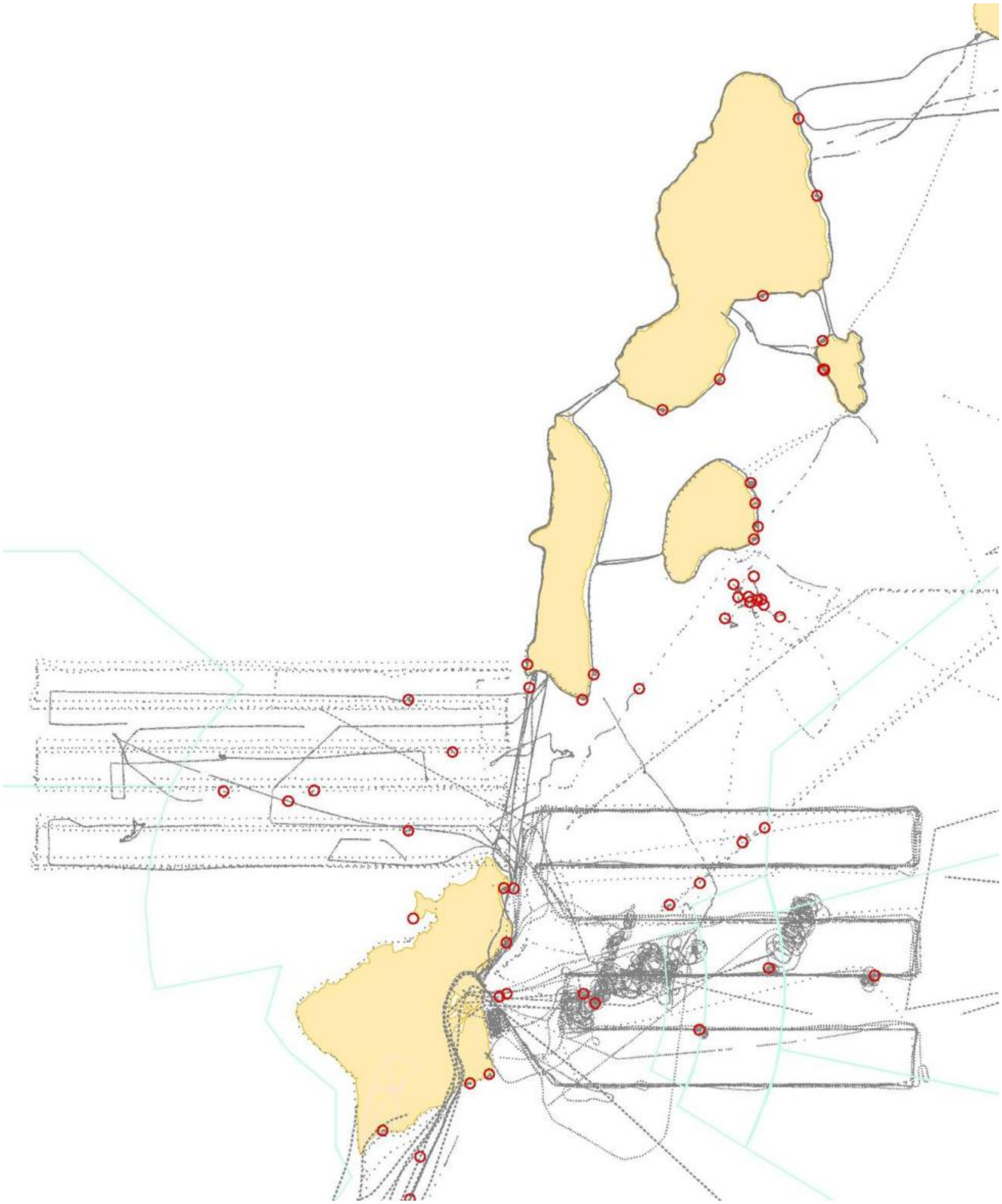

Figure 3. Detail Oahu/Four-island region: All survey tracks and all marine mammal sightings (except humpback whale)

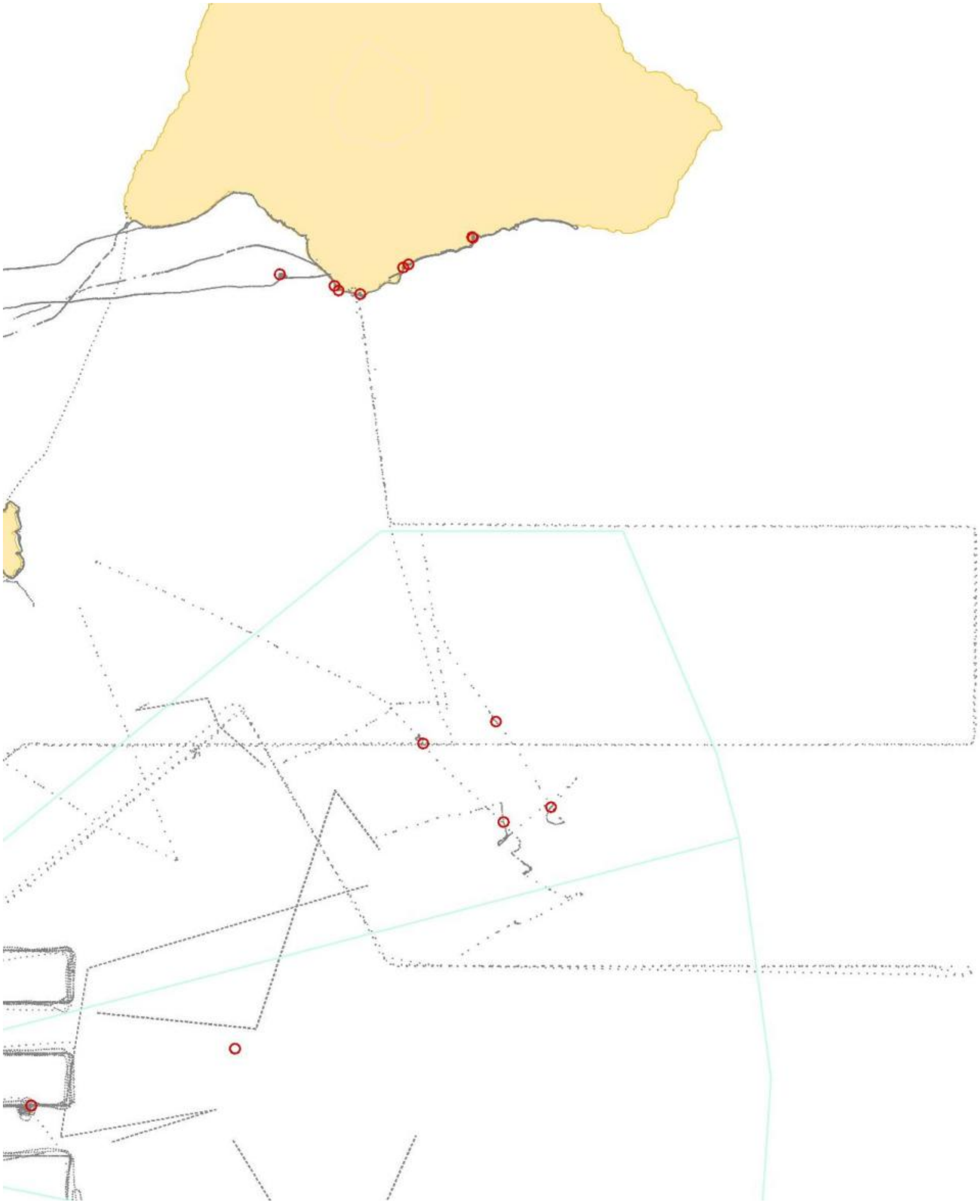

Figure 4. Detail west of Big Island: All survey tracks and all marine mammal sightings (except humpback whale)

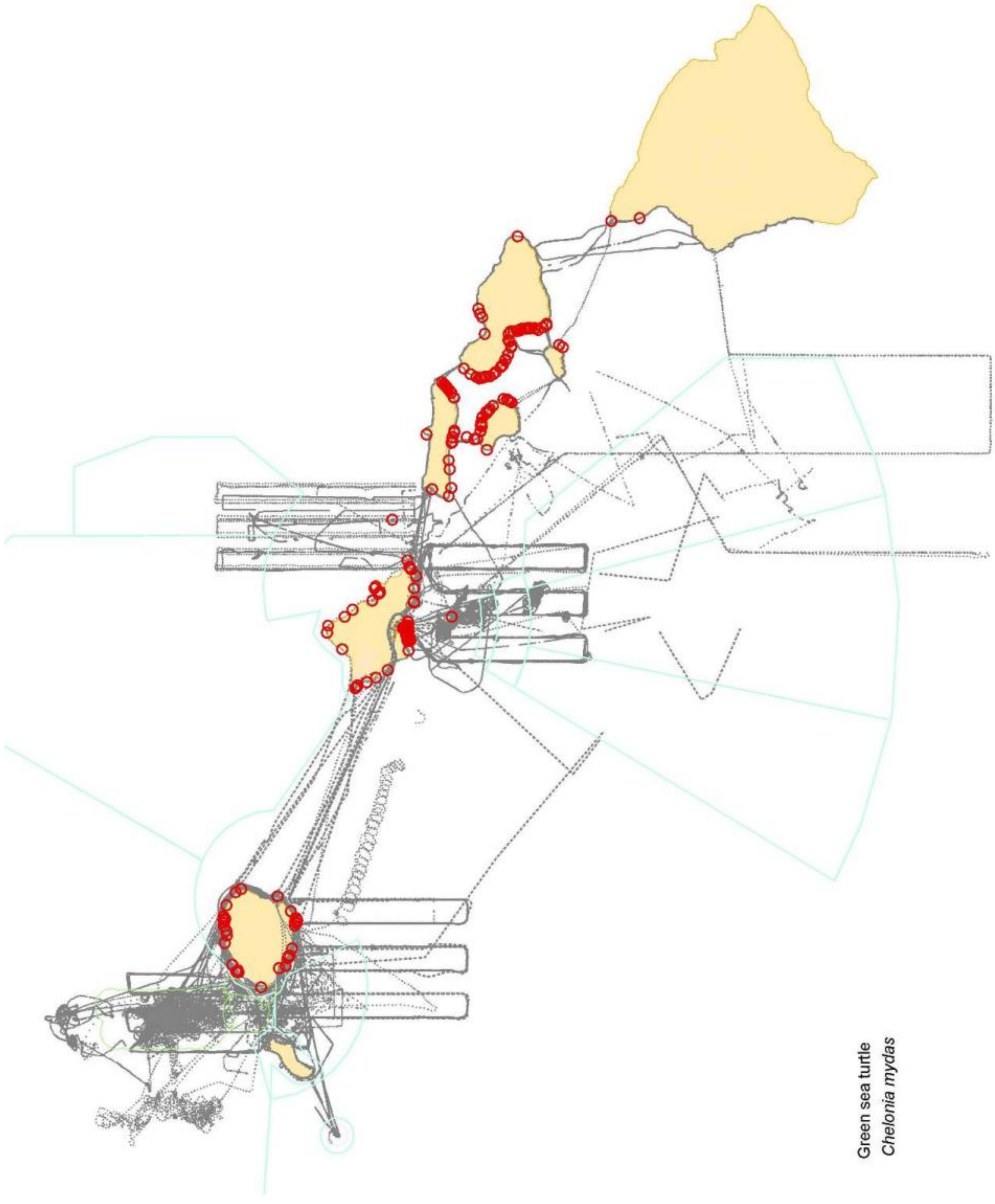

Figure 5. Green sea turtle (Chelonia mydas)

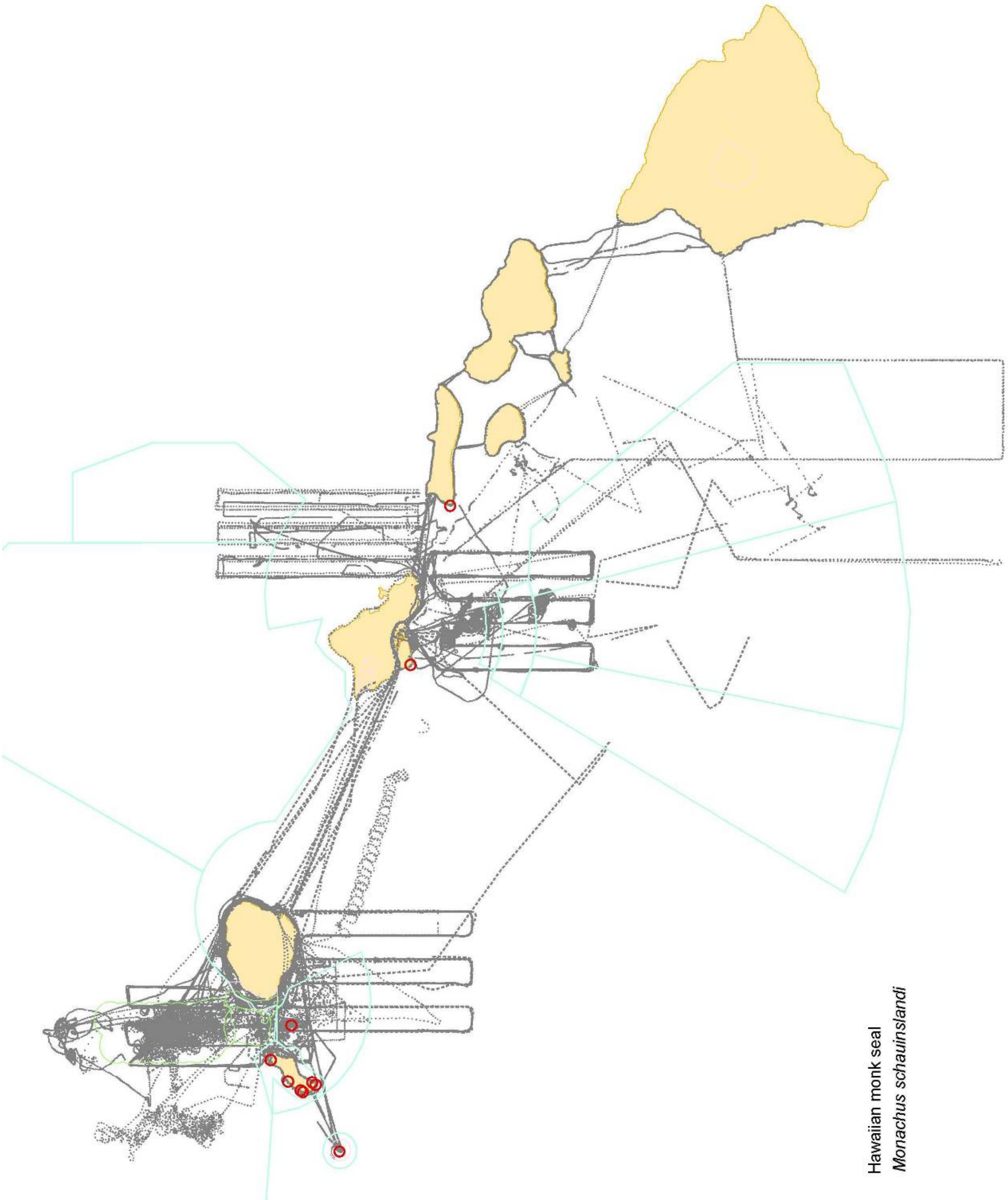

Figure 6. Hawaiian monk seal (Monachus schauinslandi).

Note: All sightings were of hauled-out animals on the shore, except for one sighting of a swimming animal in the channel between Kauai and Niihau.

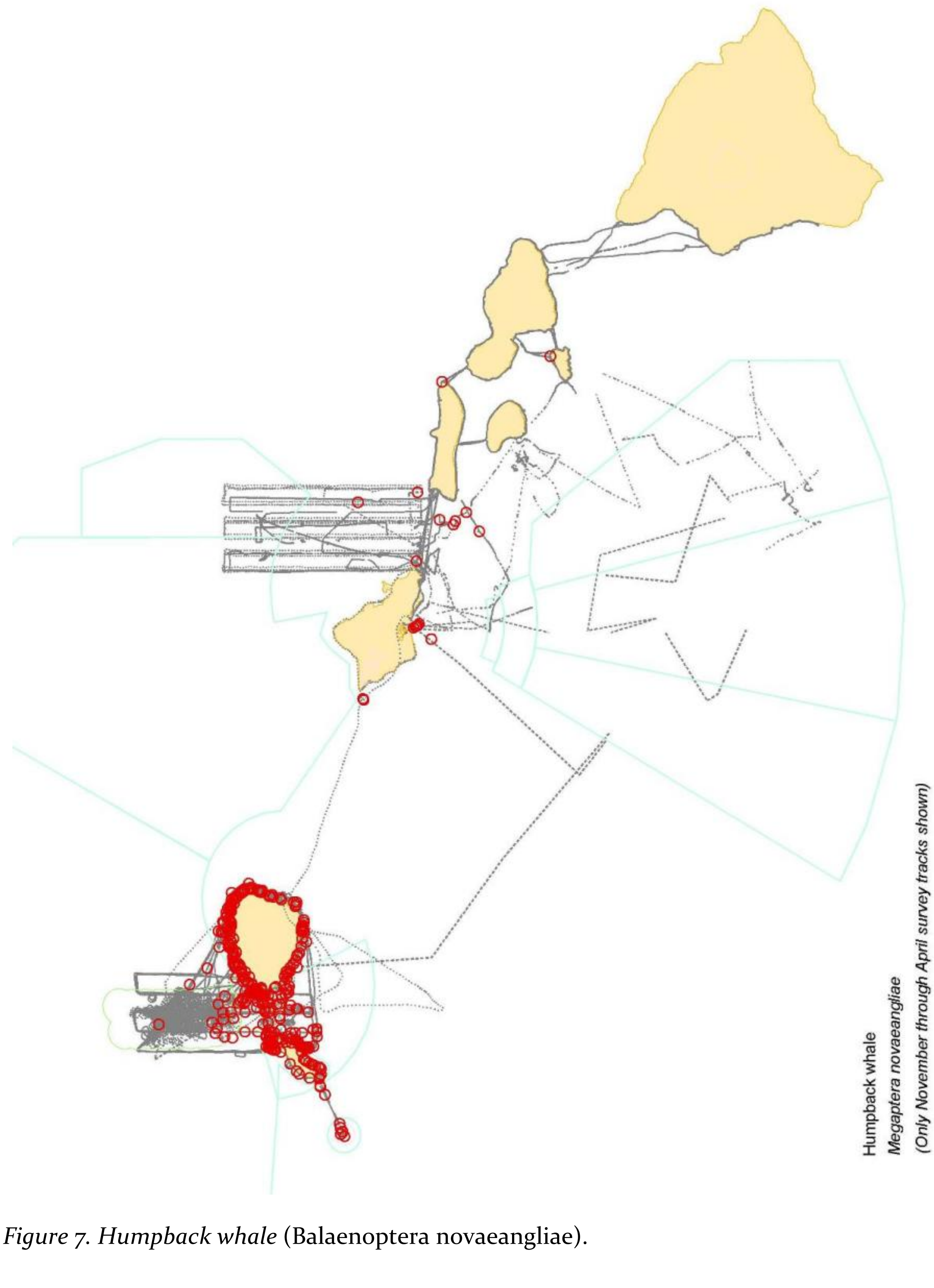

Figure 7. Humpback whale (Balaenoptera novaeangliae).

Note: Only November through April survey tracks shown; see section 2.1.1 for a list of surveys represented in this figure.

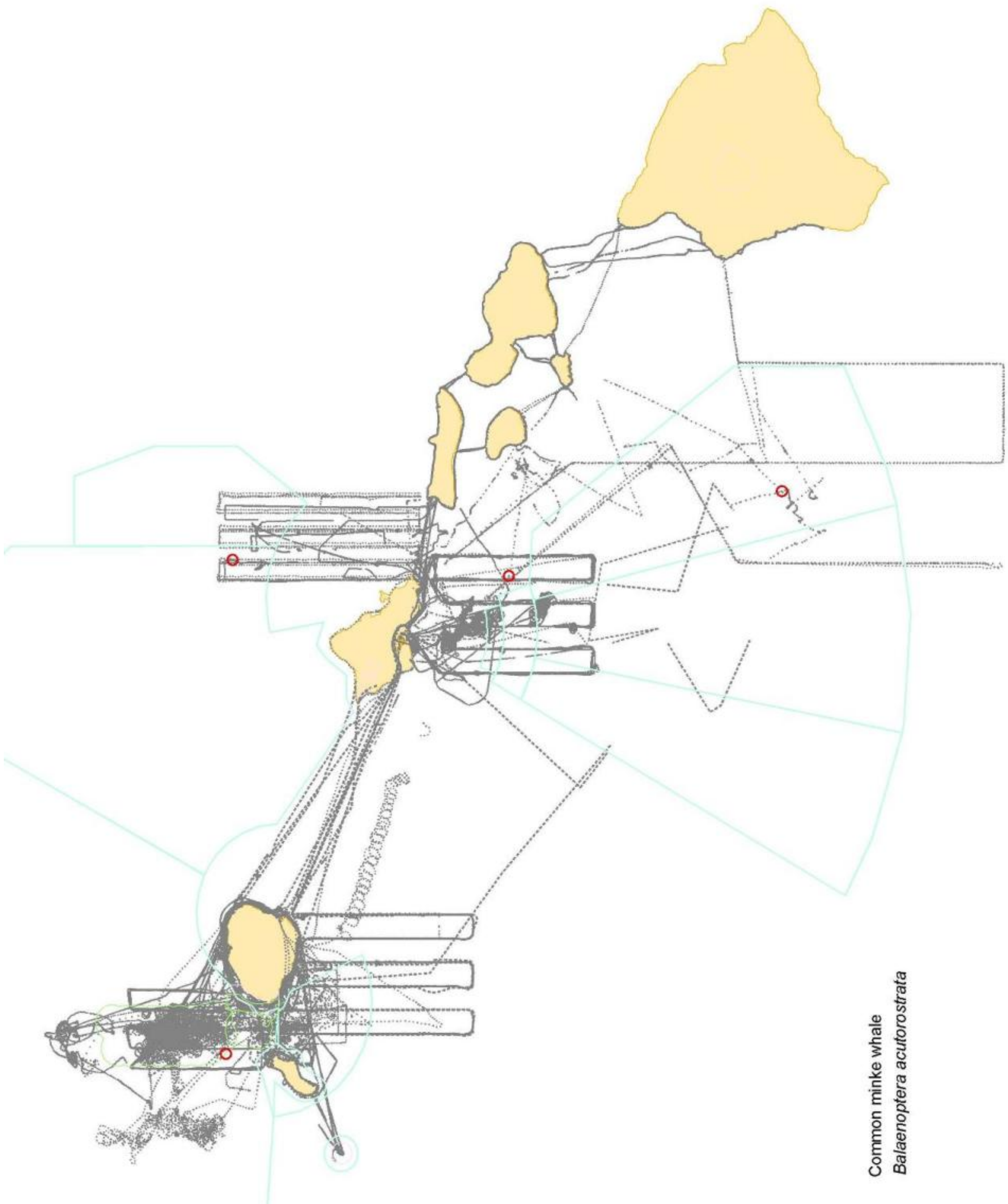

Figure 8. Common minke whale (Balaenoptera acutorostrata).

Note: Sightings represent observations labeled as minke whale, as well as those labeled "unidentified small whale" or "probable minke whale."

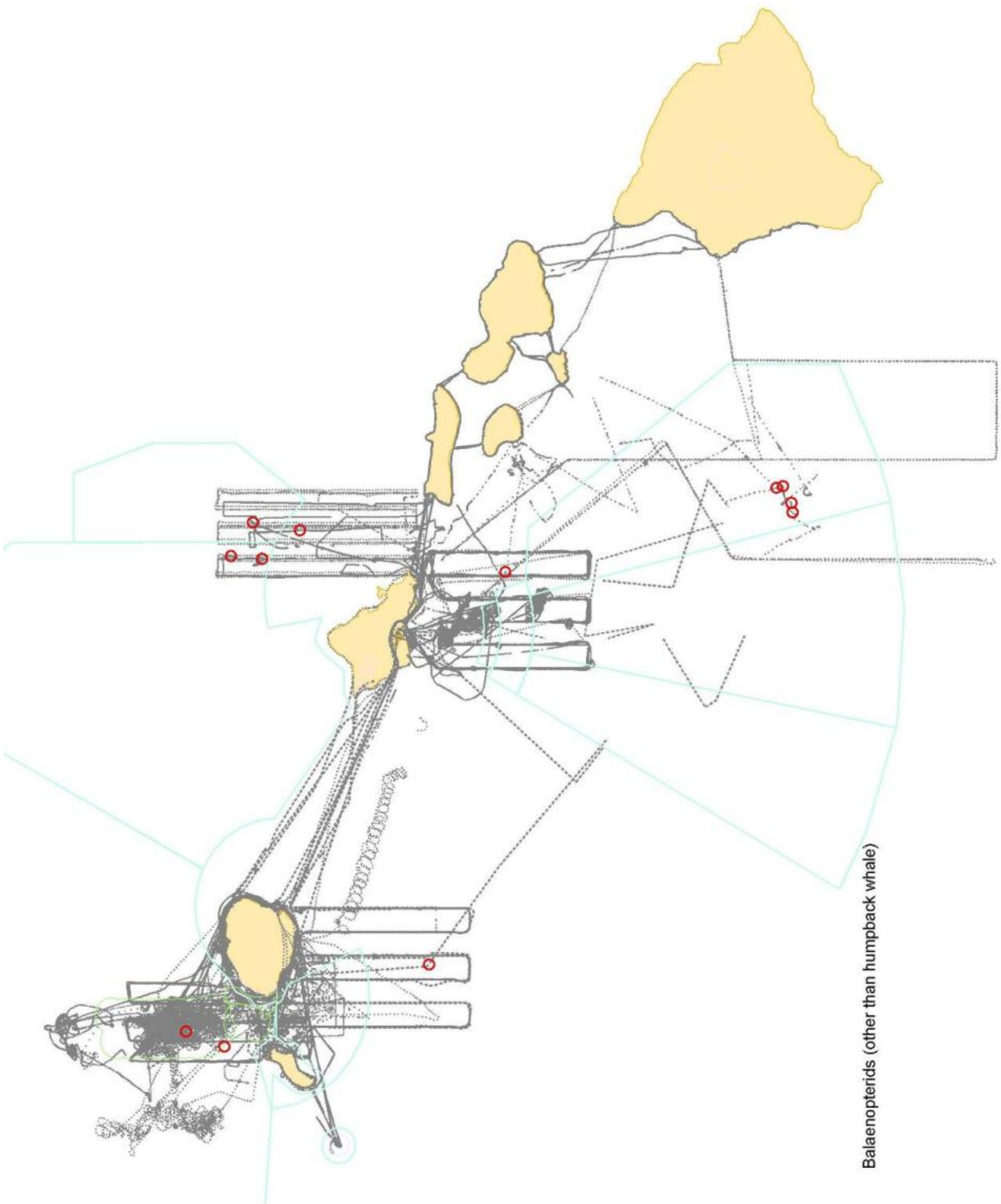

Figure 9. Balaenopterids other than humpback whale.

Note: Sightings represent those labeled as "unidentified large whale" outside of the winter humpback season, those labeled as "unidentified non-humpback balaenopterid" during the season, as well as sightings labeled as sei whale *(Balaenoptera borealis)*, Bryde's whale (*Balaenoptera edeni*) and minke whale (*Balaenoptera acutorostrata*). No fin whales (*Balaenoptera physalis*) were positively identified in the included surveys.

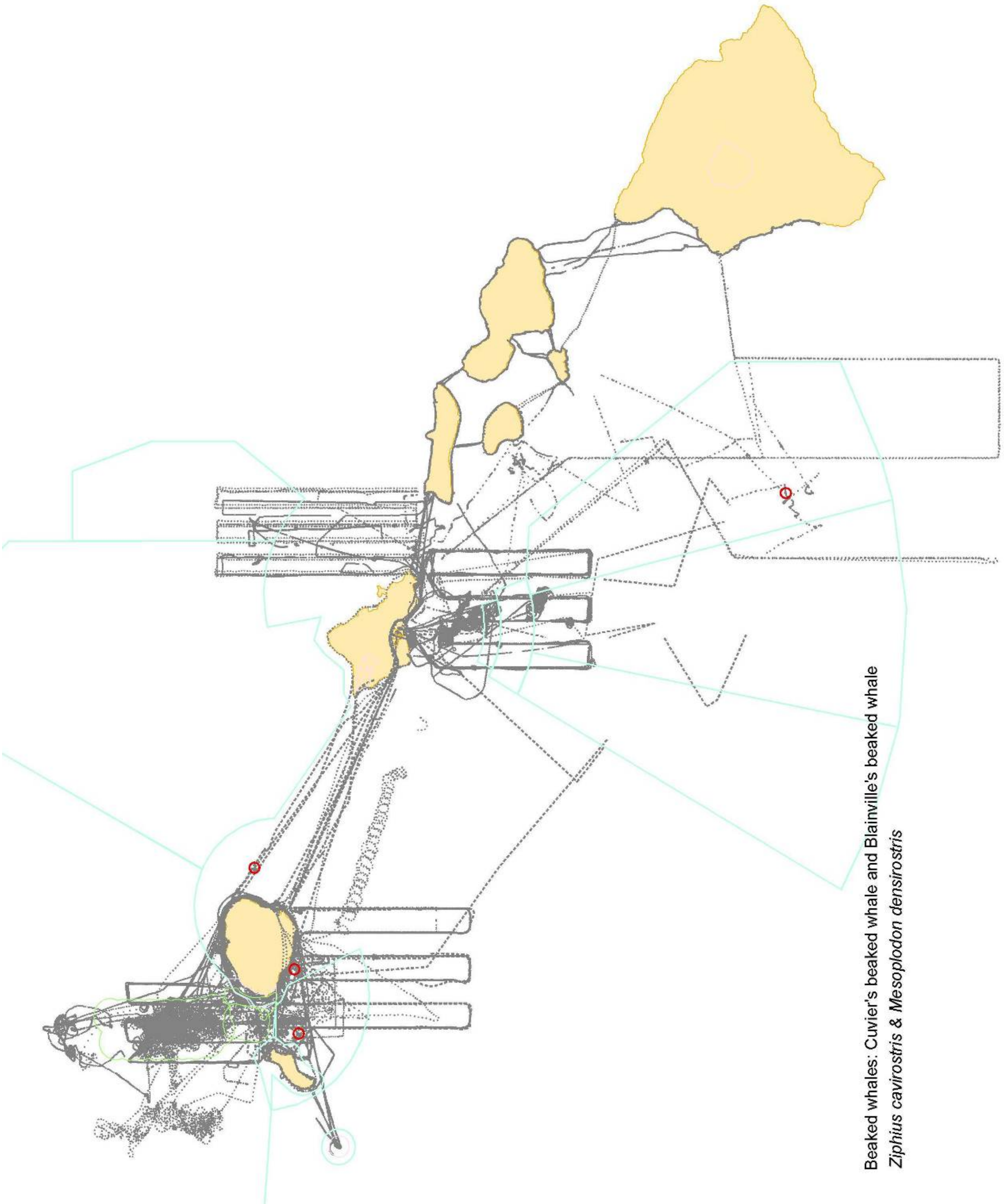

Figure 10. Beaked whales: Cuvier's beaked whale (Ziphius cavirostris) *and Blainville's beaked whale* (Mesoplodon densirostris).

Note: One sighting was "unidentified Mesoplodon." No sightings of Longman's beaked whale (*Indopacetus pacificus*) were made in the included surveys.

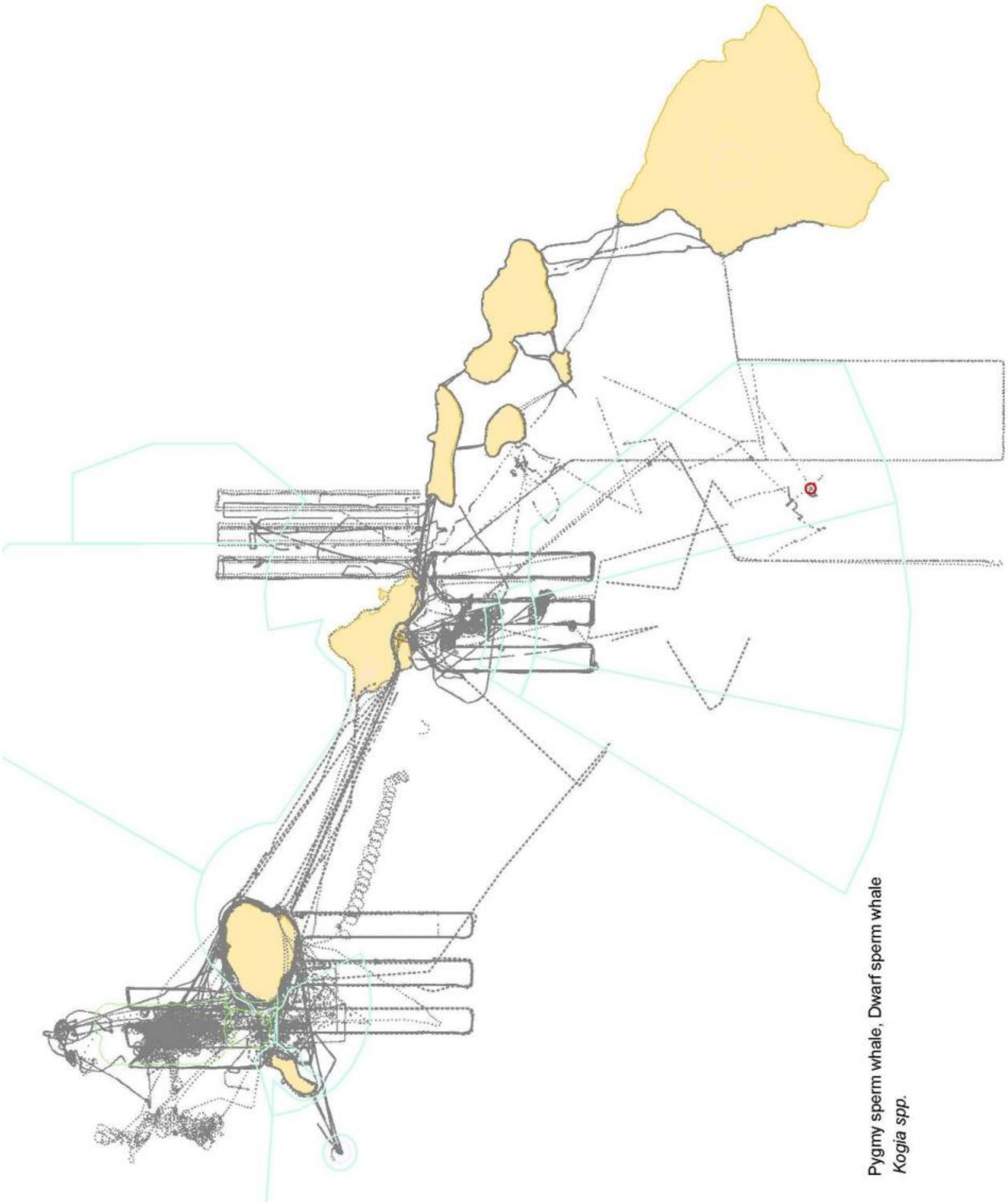

*Figure 11: Pygmy and Dwarf sperm whale (*Kogia *spp.)*

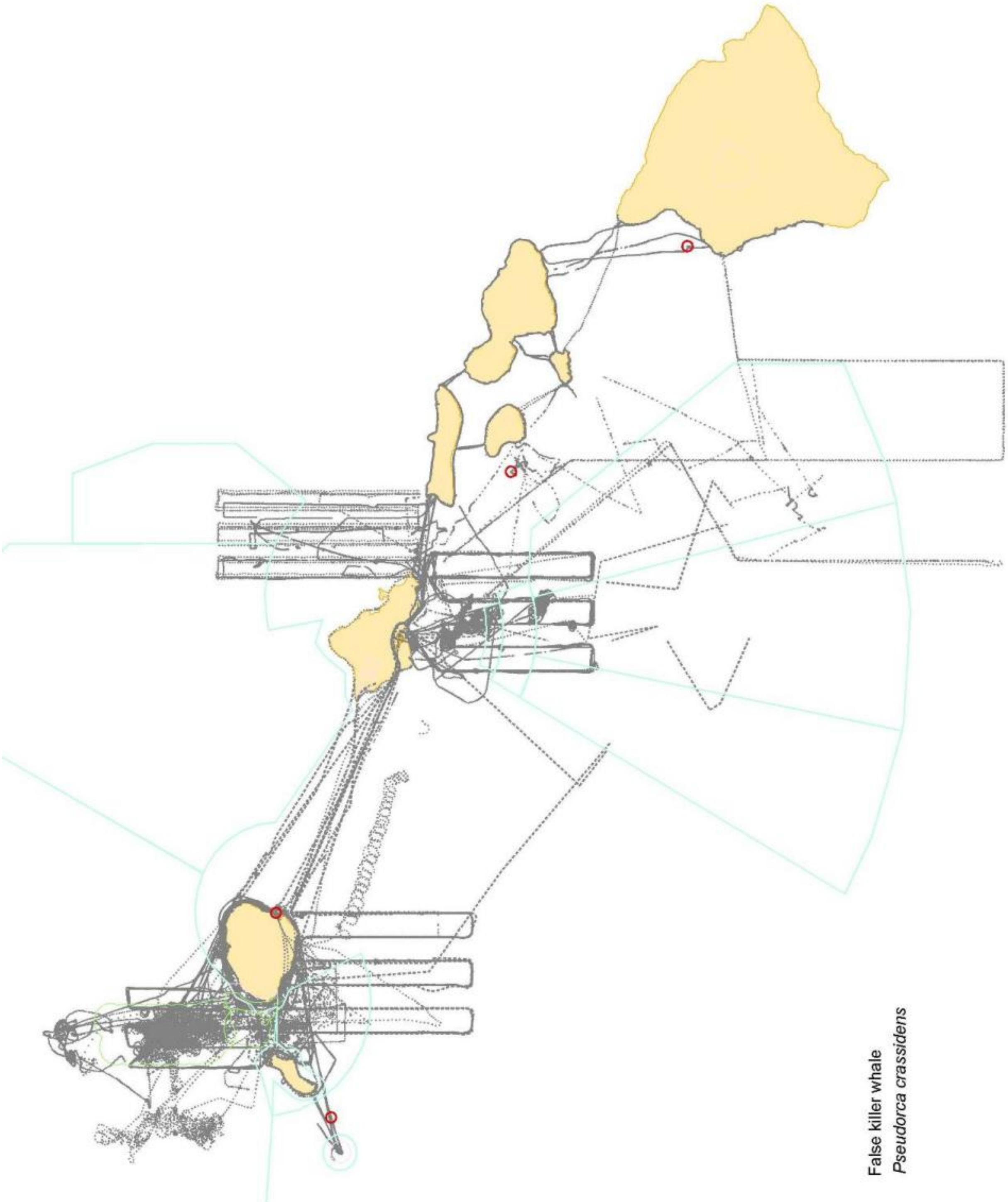

Figure 12: False killer whale (Psuedorca crassidens).

Note: the sightings do not differentiate between population stock, although the sighting at Ka'ula islet (the sighting farthest west) was confirmed to not be composed of known members of the Hawaii Insular stock.

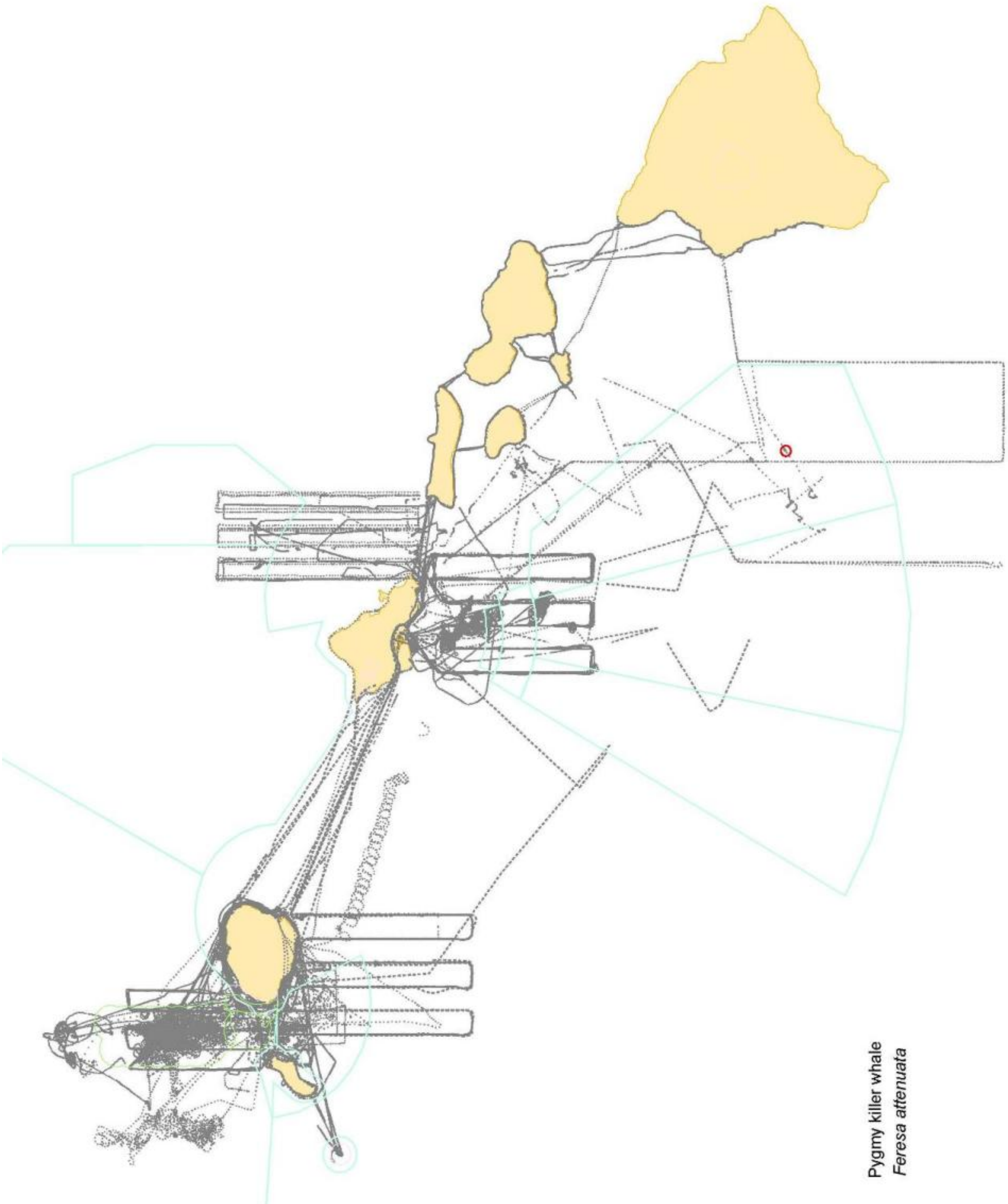

Figure 13: Pygmy killer whale (Feresa attenuata)

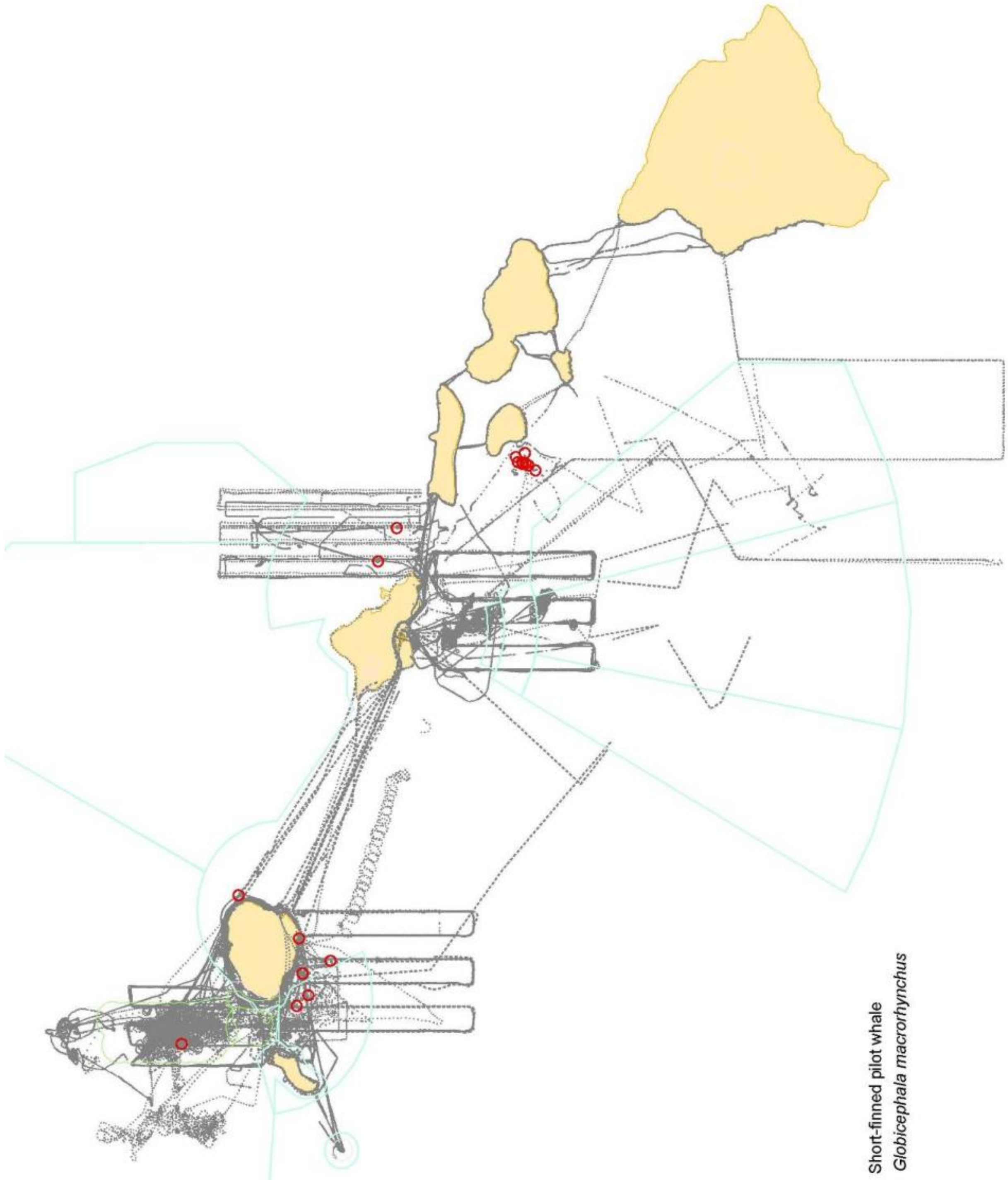

Figure 14: Short-finned pilot whale (Globicephala macrorhynchus)

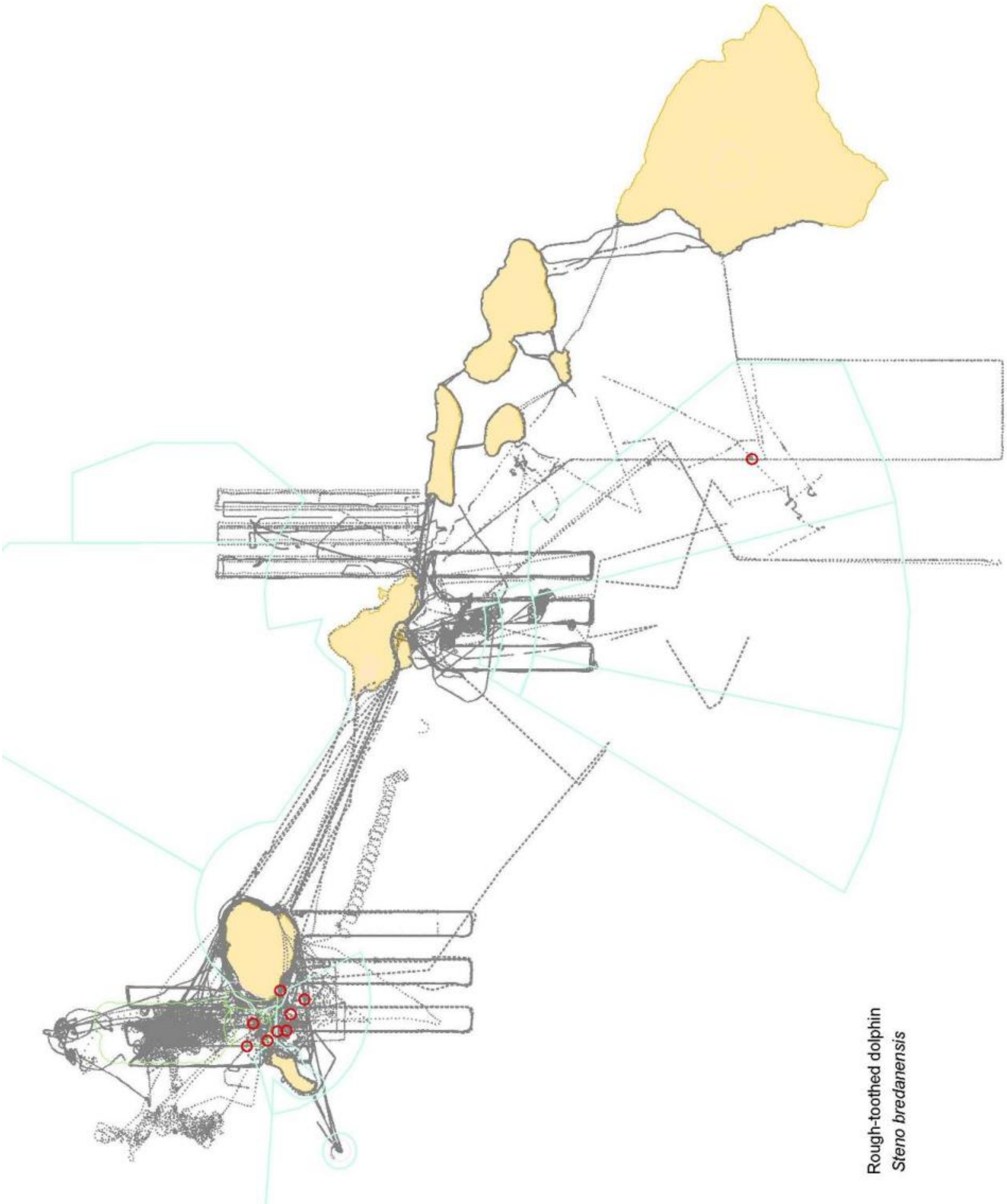

Figure 15: Rough-toothed dolphin (Steno bredanensis)

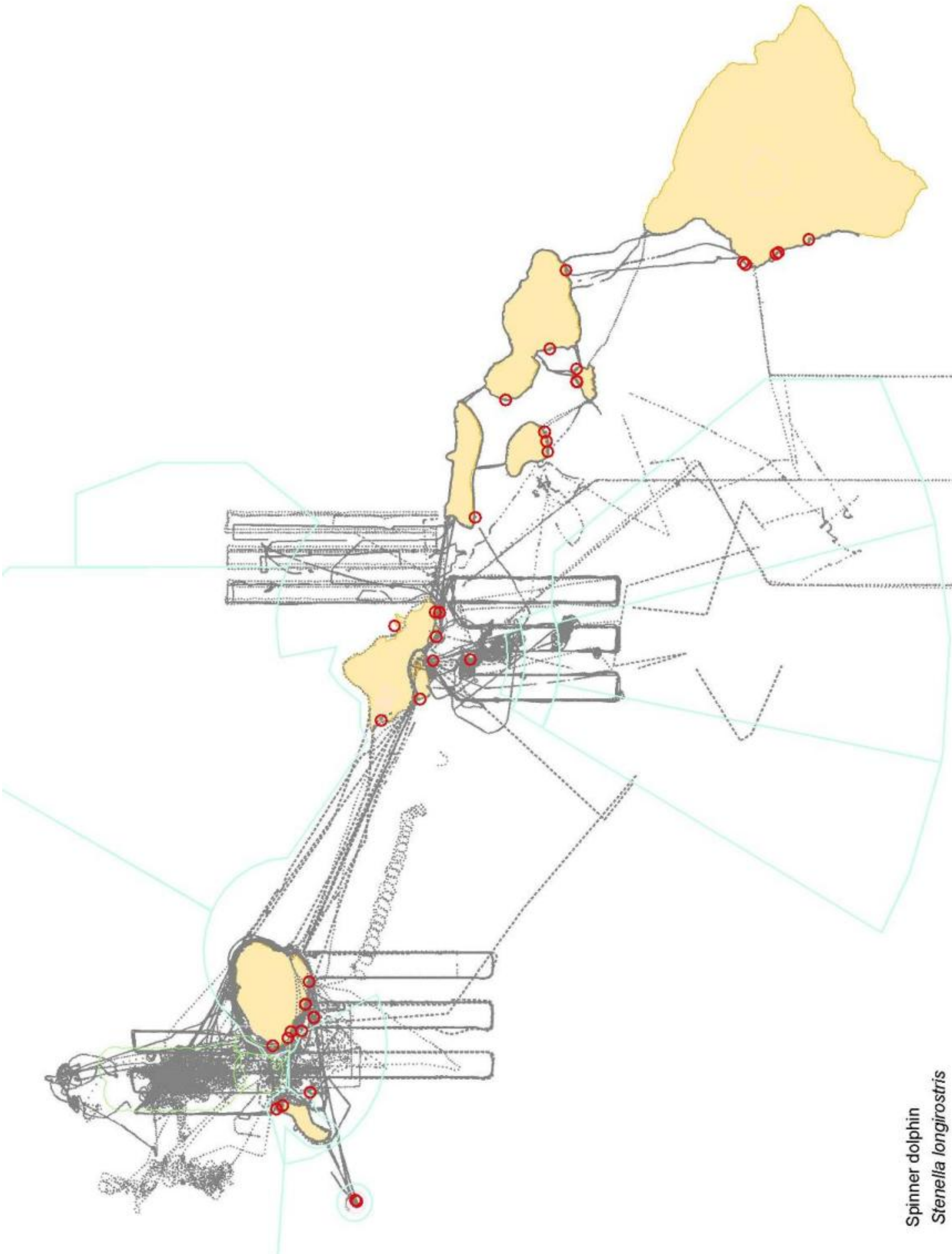

Figure 16. Spinner dolphin (Stenella longirostris)

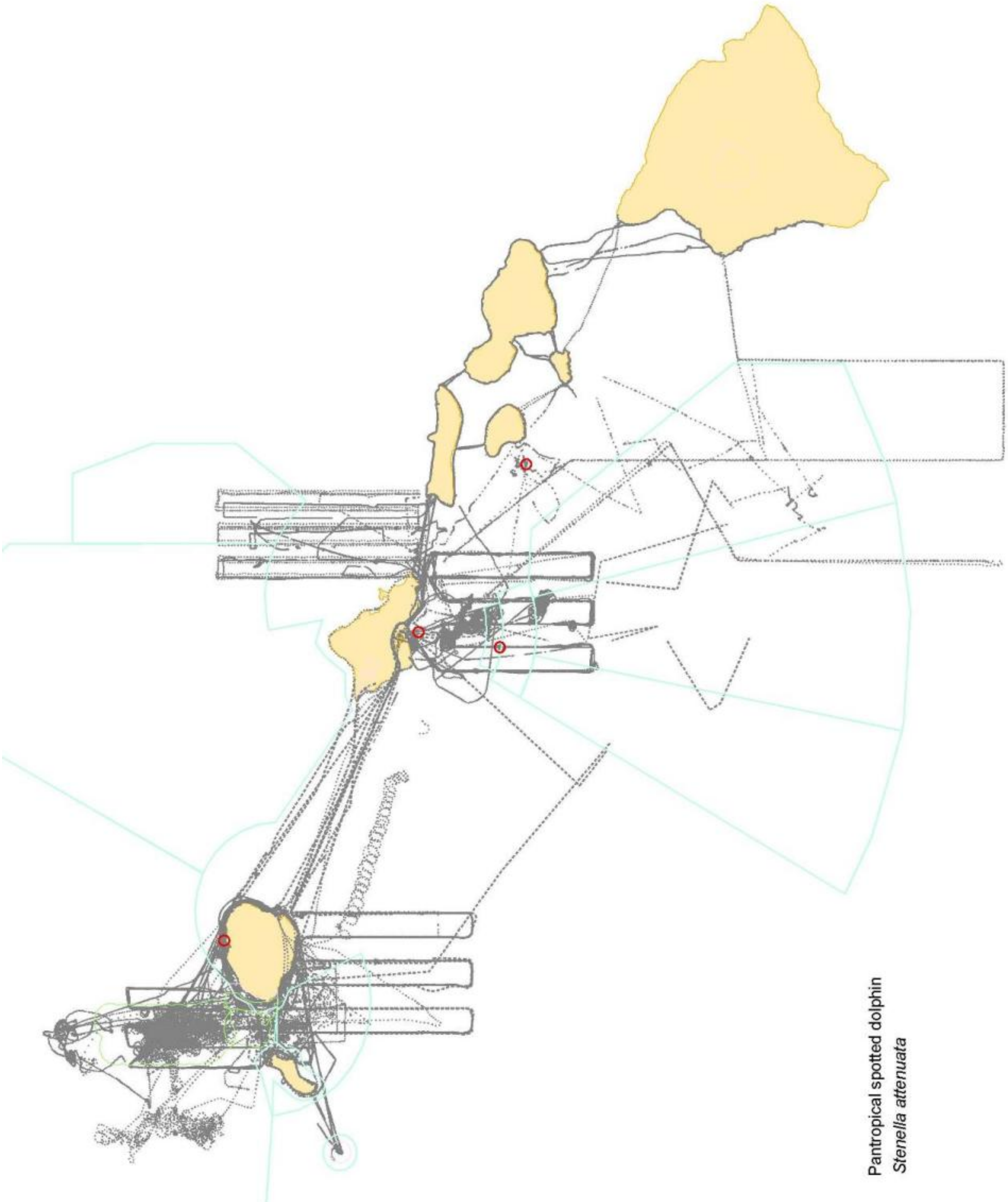

Figure 17. Pantropical spotted dolphin (Stenella attenuata)

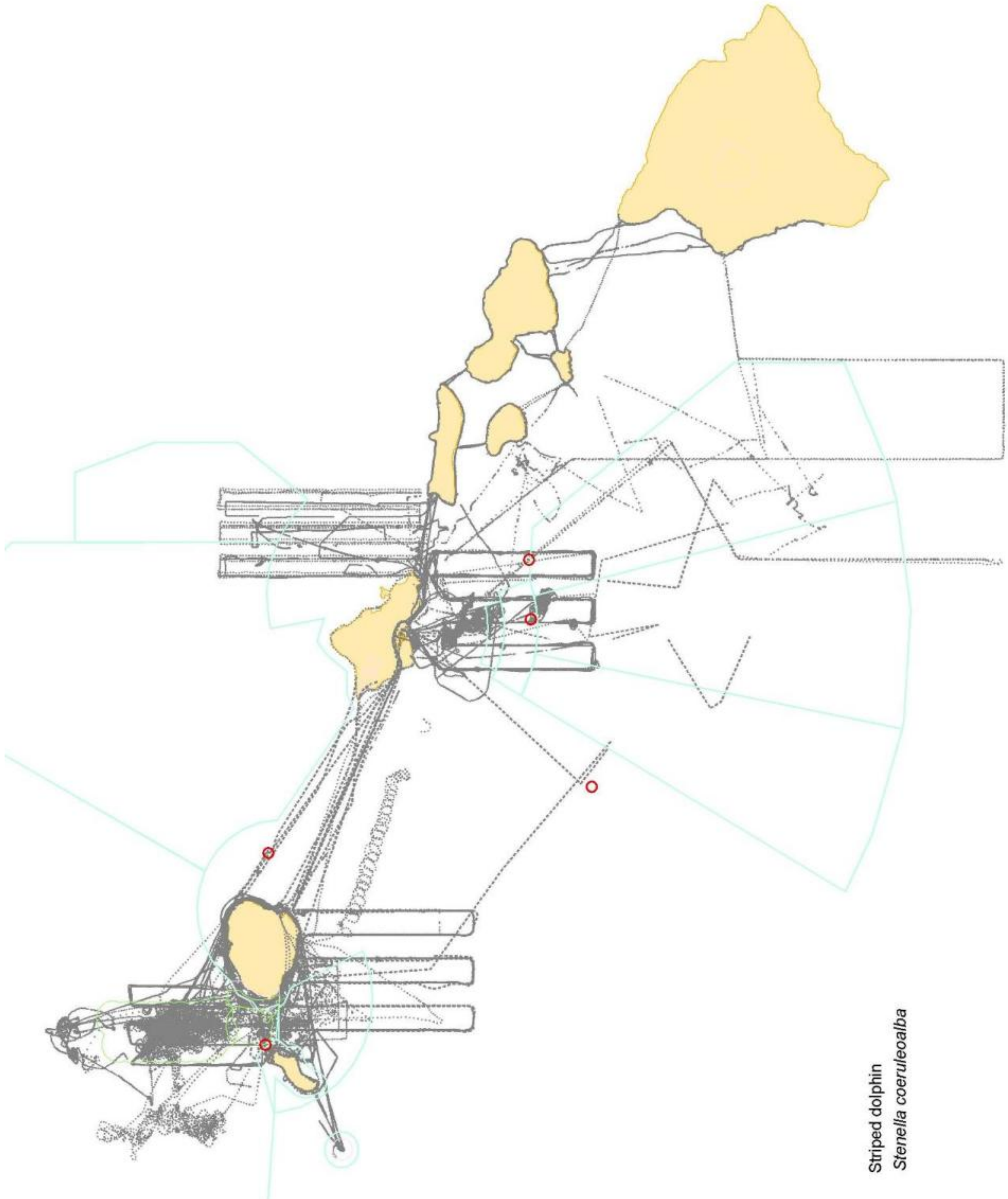

Figure 18. Striped dolphin (Stenella coeruleoalba)

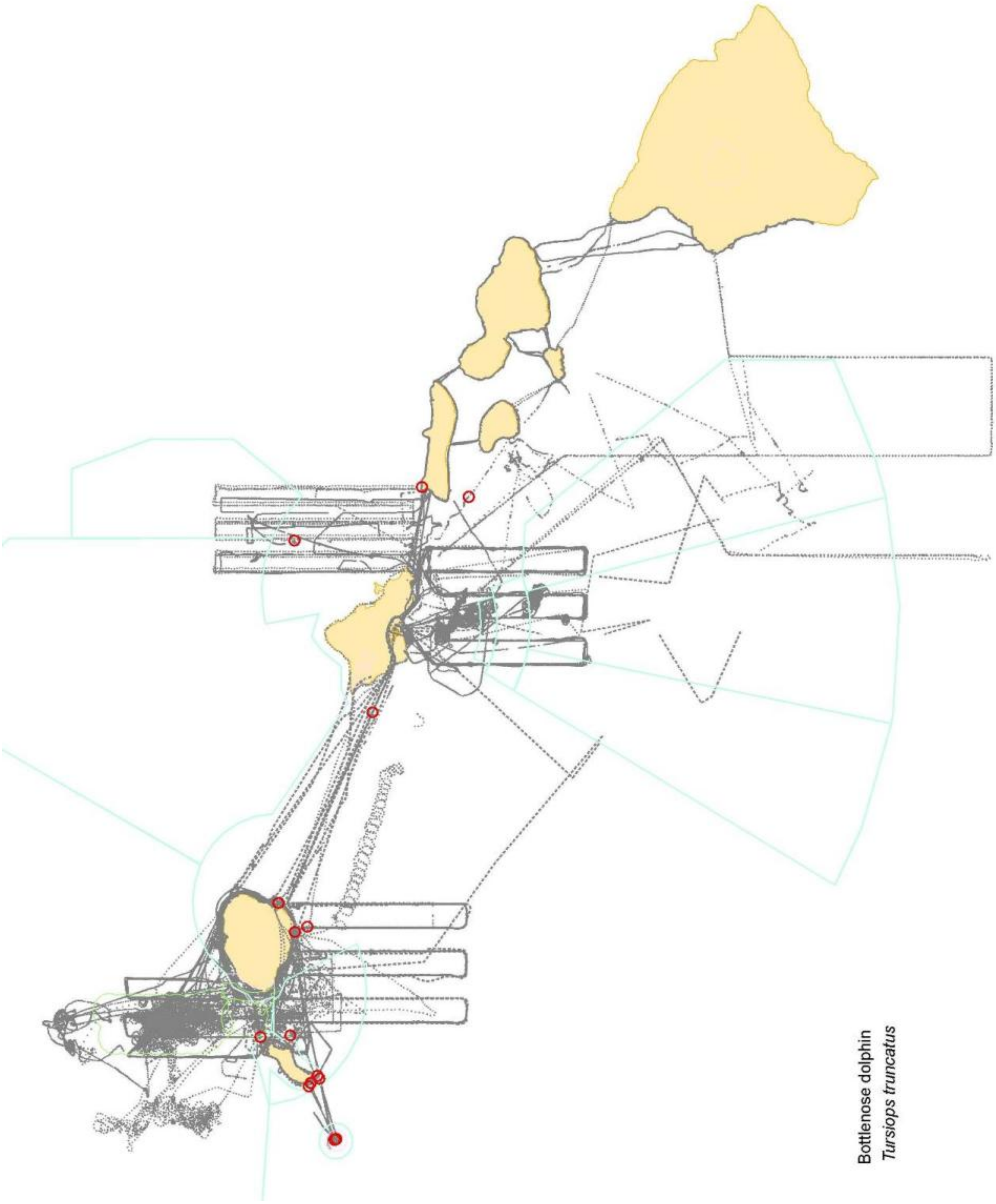

Figure 19. Bottlenose dolphin (Tursiops truncatus)

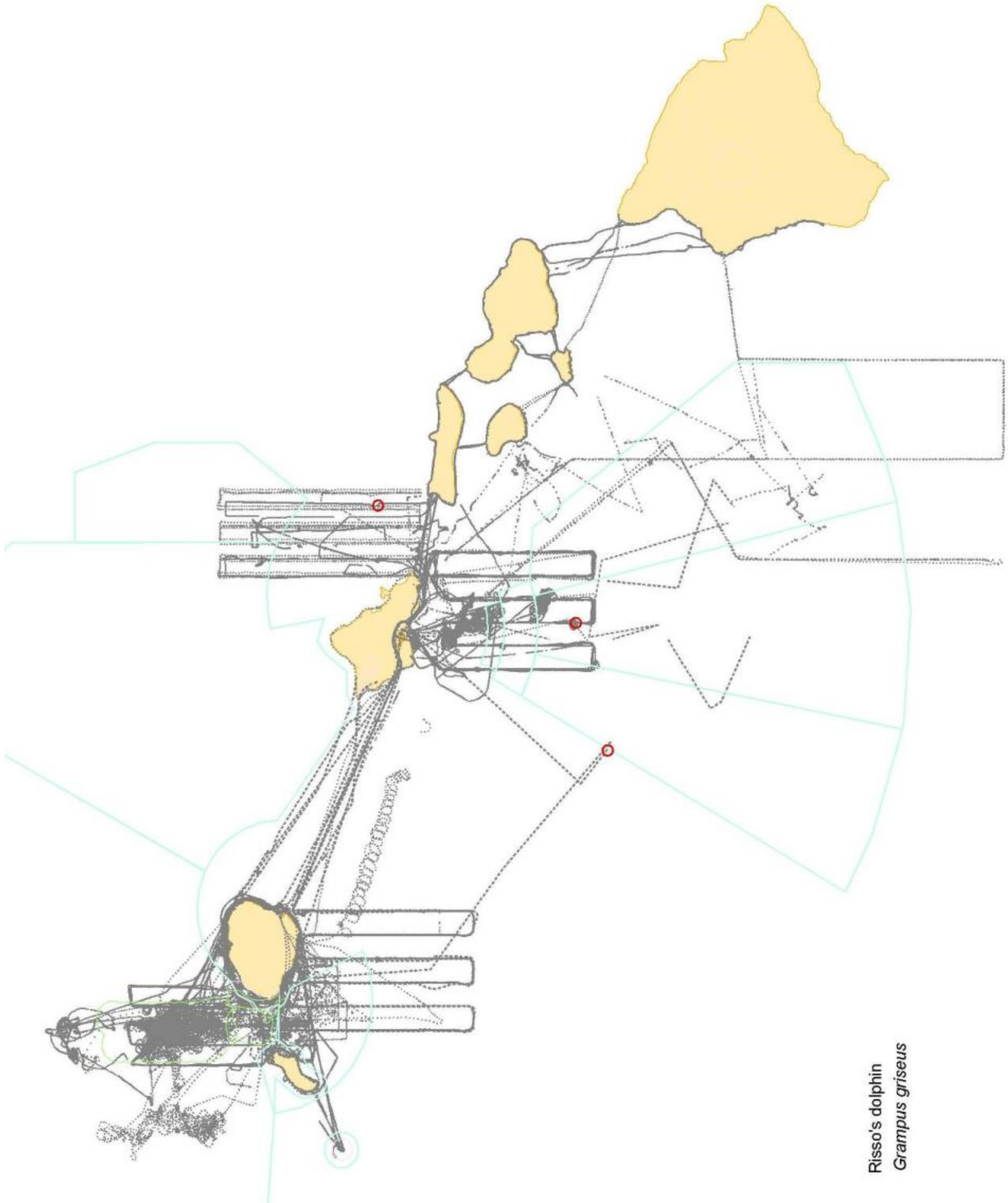

Figure 20. Risso's dolphin (Grampus griseus)

4. DISCUSSION

4.1 Preliminary Conclusions

This report represents the initial phase of integrating results over the entire course of all visual surveys conducted for the Commander, U.S. Pacific Fleet's marine species monitoring program. A primary goal is to use the results from the integration of data to help inform future management decisions.

Frequency of sighting: Although power analyses were not performed in association with this data compilation, it appears that developing density estimates for most species would require large levels of effort, potentially at multiple times greater than the total completed so far. In particular, some species were sighted only once across all survey efforts (e.g., *Feresa attenuata, Kogia spp.*), beaked whales were sighted only three times across two species (*Ziphius cavirostris and Mesoplodon densirostris)*, whereas other species were not sighted at all (e.g., *Physeter macrocephalus, Peponocephala electra, Indopacetus pacificus, Balaenoptera physalus, Eretmochelys imbricata*).

Species that may be more amenable to some shorter-term density analyses include the green sea turtle (*Chelonia mydas)*, spinner dolphin (*Stenella longirostris)*, and the humpback whale (*Megaptera novaeangliae)*. Also in certain coverage areas, species that may be amenable to shorter-term density analyses include the rough-toothed dolphin (*Steno bredanensis)* in the channel between Kauai and Niihau, and the short-finned pilot whale (*Globicephala macrorhynchus)* to the southeast of Kauai and Lanai.

Shore and offshore: Notable offshore observations of species that are typically seen either nearshore or onshore include two offshore sightings of green sea turtles, and one offshore sighting of a Hawaiian monk seal (*Monachus schauinslandi)* (Figs. 5, 6). With regard to shoreline surveys, this methodology (both aerial- and vessel-based) has enabled the study of hauled-out monk seals at Niihau and Ka'ula, although it is notable that relatively few animals were sighted on other islands: one each on Oahu and Molokai, and no animals sighted hauled out on Kauai, Maui, Lanai, Kahoolawe, and the Big Island (Fig. 6). It is unknown whether this observational pattern is due to actual relative distribution of animals, or the interaction of artifactual variables such as relatively greater observer attentiveness on smaller islands, type or color of terrain, relative time of day of flights, or observational platform (i.e., vessel or aerial). In contrast Green sea turtles have not been sighted at Niihau or Ka'ula, but have been sighted frequently on all other islands except for the Big Island, where a few sightings have been made on the northern end of the west coast (Fig. 5). Also notable is that the aerial surveys during events and shoreline surveys, which are conducted before, during and after Navy training events using MFAS, have in total detected no marine mammals demonstrating unusual behavior, stranded, or in distress.

Areas of interest: Areas that have been frequently surveyed, but with relatively low numbers of sightings include to the south of Kauai, north of the channel between Oahu and Molokai, and the majority of the northern half of the instrumented underwater ranges at PMRF. The waters offshore of PMRF between Kauai and Niihau have been heavily surveyed and have yielded a moderately high number of sightings. Areas that have not been surveyed that are within or adjacent to potential exercise areas include waters adjacent to the underwater range at PMRF, including to the north of Niihau toward Middle Bank, to the south of Niihau, and to the north of

Kauai. Other areas that have not been surveyed include to the north of Oahu, north of Oahu, and the offshore waters which are both south of the four-island region and west of the Big Island. Areas that have been infrequently surveyed, but that have still yielded relatively higher numbers of sightings include waters offshore the leeward side of Lanai and the seamount chain west of and in the lee of the Big Island (e.g., Jaggar and Perret seamounts).

Types of surveys: The included survey protocols have included line transect, transits to areas of monitoring interest, shoreline surveys, and follows of or embarks upon Navy assets. Relatively under-represented are opportunistic surveys that follow coverage of estimated marine mammal habitat such as depth isobaths, while at the same time seeking ideal sightings conditions in calmer weather typically found on the leeward sides of each island. Also, no shore-based surveys utilizing a theodolite to fix sighting positions are represented in the list of included surveys.

4.2 Future directions

After the initial summary of survey effort and sightings contained in the present report, future goals of the data integration task for visual surveys in the HRC include:

1. Continuing to collect data from upcoming field efforts

2. Collecting archival data from past efforts where trackline raw data was not originally delivered by the contractor, or is not otherwise immediately available or yet delivered:

    a. The five surveys listed in section 2.2.1 for which electronic deliverables of the survey track and sightings were not available, and the UNDET survey listed at the 2.2.2.
    b. 2011 Feb 16-March 5 SCC and USWEX aerial surveys (HDR, Contract #N62470-10-D-3011 CTO KB07): electronic deliverables currently pending
    c. 2011 July M3R tagging survey (HDR/CRC #N62470-10-D-3011 CTO KB07, partially funded by N45)

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APPENDIX M. Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011

Project Annual Report

Primary Investigator: Charles Littnan, Lead Scientist, Hawaiian Monk Seal Research Program, National Marine Fisheries Service

Submitted by: Kenady Wilson, Scientist III, Hawaiian Monk Seal Research Program, Ocean Associates Inc.

Funding Source: U.S. Pacific Fleet

Permit: National Marine Fisheries Service Permit No. 10137 TO TAKE PROTECTED SPECIES FOR SCIENTIFIC RESEARCH AND ENHANCEMENT PURPOSES

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EXECUTIVE SUMMARY

As of August 1, 2011, 21 monk seals were instrumented as part of this NMFS-Navy/DOD collaborative project. In 2010, 11 seals were tagged; however, four seals lost their tags due to a bad batch of epoxy and data were only recovered for 7 animals (1F, 6M). In 2011, eight new animals were tagged, and two seals were tagged that had also been instrumented in 2010. Data were recovered for 6 of these animals (1F, 5M). Dive data for 3 of the 10 seals tagged in 2011 were never downloaded to the server and were therefore not included in the analyses. Additionally, data for one seal tagged on Molokai (RW30) was not visible at all on the server. It is unclear what may have caused these malfunctions, but steps are being taken to remedy these issues in the future.

Data are currently being analyzed to identify monk seal home ranges and core areas of use, and to examine variation in monk seal diving and foraging behavior. These analyses give insight into how monk seals move and utilize their available habitat. During both deployment periods, monk seals tended to stay within the 600 m depth contour surrounding the MHI and neighboring banks, and most dove to depths < 100 m. Their foraging trips typically lasted less than one day, but some seals were observed to take trips lasting 1-3 weeks in duration. Continued monitoring will reveal if these extended trips are more common than previously assumed. Understanding the duration of time spent foraging, the type of foraging occurring, and the amount of time spent foraging in specific areas is an important step in thoroughly understanding monk seal behavior and will provide good baseline data for future comparisons regarding the impact of Navy activities on their behavior.

The next phase of analysis will include a comparison of current home range calculations to home ranges and core areas that are calculated via a mechanistic home range model. These models provide a more detailed understanding of animal movement and habitat use by incorporating stochastic processes into the model. They enable the use of behavior metrics and habitat variables within the model thus allowing these variables to influence the designation of a home range or core area rather than defining home ranges solely on a seals' presence within an area. Additionally, the percent of time seals spent within the HRC will be calculated and a model will be developed to analyze behavior bouts (at varying time-scales) to detect 'significant' changes in behavior. These behavior events will then be compared to periods of HRC activities to look for correlations.

INTRODUCTION

Hawaiian monk seal abundance is falling from a 2007 estimate of 1,146 individuals. Most monk seals reside in the remote Northwestern Hawaiian Islands (NWHI) where the decline is approximately 4% yr^{-1}. A smaller, recently established population in the main Hawaiian Islands (MHI) has greater survival rates and the total number of seals is increasing. The estimated MHI intrinsic rate of population growth is 1.13 compared to a range from 0.89 to 0.98 in the NWHI. While this increasing population in the MHI provides some hope for the species' continued existence, it brings with it a new host of potential management concerns.

There are a variety of natural and anthropogenic threats that exist in the MHI including human-interactions (i.e. fisheries, beach disturbance, boat activities, pollution etc.) and disease exposure (from both domestic and feral sources). The question has also been raised whether or not activities associated with naval operations in the Hawaii Range Complex (HRC) may be impacting monk seals at-sea and currently, no data exists to assess any impact or disturbance of these activities to seals. To address this question it is necessary to quantify and compare monk seal at-sea behaviors both outside and during periods of HRC activities. Very little is currently known about the at-sea behavior and ecology of these MHI seals. Telemetry studies to understand their foraging behaviors and habitat use are one of the first critical steps to help inform management actions for the species.

In 2010, NOAA Fisheries' Hawaiian Monk Seal Research Program (HMSRP) and U.S. Navy Pacific Fleet Environmental TO initiated a collaborative research effort to investigate potential impacts of naval activities in the HRC on monk seals. This multi-year study is ongoing and the intent of this interim report serves as an update on completed field activities and review current results and future analyses.

Tag Capability

The HMSRP uses new technology to better understand the foraging behavior and habitat use of main Hawaiian Island monk seals. The Sea Mammal Research Unit (SMRU) has developed a telemetry tag using global position system (GPS), GSM modem (cellular phone) and standard behavior recording technologies in order to increase the quality and amount of data researchers obtain in marine mammal telemetry studies. This tag contains a hybrid GPS system that is capable of acquiring GPS pseudo-range data within a snapshot window of only 0.2 s. The pseudo-range data is transmitted to researchers and processed with separately downloaded GPS ephemeris data to produce high-quality GPS fixes (with a horizontal error radius of about 55m). In addition, the tag also collects and stores detailed *individual* dive behavior and haul-out information as well as temperature up-cast profiles. To transmit data to researchers, the tag utilizes a GSM modem to relay stored data via existing commercial cell phone networks. While the tag must be within approximately 20 km of a GSM base station for a data call to be established, data can be stored for up to six months in between calls, allowing animals to move large distances from base stations while still collecting detailed behavioral data. Tags are expected to be operational for up to one year or until the animal molts. In the past, monk seals tagged with these instruments have collected data from 0 – 8 months, with most seals retaining their tags for 3 - 6 months. Monk seals forage under rocks and overhangs near the ocean floor, resulting in the rough treatment of tags and data collection periods that are often shorter than the life expectancy of the tag.

Historical Findings

Very few studies have been conducted on MHI movements and habitat use. Due to technological limitations these earlier studies could not determine precise diving locations and were unable to examine complete dive records. These studies have shown that monk seals spend most of their time at sea in nearshore, neritic, marine habitats (Littnan et al. 2006). Land-based observations and volunteer sightings indicate that 35.6% of the MHI seals travel between islands throughout the year. There is high individual variability in monk seal foraging behavior; however, most foraging trips last from less than 1 day to 1-2 weeks and seals tend to remain within the 200 m depth contour surrounding the MHI and nearby banks (Littnan et al. 2006).

Multiple telemetry studies have been conducted in the NWHI to monitor monk seal behavior, diet, and habitat use; however, like in the MHI, these studies used satellite locations of varying accuracy and did not have access to the complete dive record. These studies were able to elucidate the general movements and behavior of monk seals in the NWHI and provide a baseline for future behavior studies. Seals were found to move extensively within the barrier reefs of the atolls, on the leeward slopes of reefs and islands at all NWHI colony sites, and along the Hawaiian Archipelago submarine ridge to nearby seamounts and submerged reefs and banks (Stewart et al. 2006). Most dives were less than 150 m deep, though dives of some seals exceeded 550 m. Movements and home ranges were highly variable between age and sex classes and between the different colonies (Curtice et al. 2011).

Activities and Findings as of August 2011

Figure 1. Photo of R4DF with a cell phone tag attached to the pelage of the seal.

The primary objectives of this cooperative research project were threefold:

1) Deploy cell phone tags on monk seals in the main Hawaiian Islands.
2) Monitor monk seal habitat use and behavior: determine home range sizes, foraging areas, and identify potential foraging hot spots of seals in the MHI.
3) Identify potential changes in monk seal behavior in relation to Navy activities in the MHI.

Objective 1: Cellphone Tag Deployments in MHI

During the first year of deployment, three, week-long trips were made to Kauai where we deployed 4 instruments, two trips were made to Molokai with 4 instruments deployed, and 3 instruments were deployed opportunistically on Oahu (Table 1). As of August 2011, 10 additional tags were deployed as part of the 2nd year of funding. Tags were deployed on Kauai (3), Oahu (2) and Molokai (5). The remaining tags will be deployed opportunistically on Oahu.

Table 1. Hawaiian monk seals captured and instrumented in the Main Hawaiian Islands. Bold font indicates seals used in current analyses.

Seal ID	Tag #	Age	Sex	Deploy Site	Deploy Date	Comments
2010						
R012	**11393**	**Adult**	**M**	**Oahu**	**3.1.2010**	
R018	**11478**	**Adult**	**M**	**Kauai**	**6.9.2010**	
R4DI	**11337**	**SubAdult**	**M**	**Kauai**	**2.9.2010**	**tag fell off**
RE70	**11420**	**Adult**	**M**	**Molokai**	**3.27.2010**	
RI11	**11419**	**Adult**	**M**	**Molokai**	**3.26.2010**	
RI13	11392	Adult	M	Molokai	3.26.2010	tag fell off
RK05	11475	Adult	M	Kauai	2.10.2010	tag fell off
RO28	11423	SubAdult	F	Kauai	2.11.2010	tag fell off
RR70	**11396**	**Adult**	**M**	**Oahu**	**6.29.2010**	
unk	11170	Adult	M	Molokai	3.28.2010	No permanent ID
R4DF	**11476**	**SubAdult**	**F**	**Oahu**		
2011						
RH42	11666	A	M	Molokai	1.21.2011	no dive data
RW30	11626	SubAdult	F	Molokai	1.22.2011	
RB24	**11424**	**SubAdult**	**F**	**Kauai**	**1.25.2011**	
R018	**11668**	**A**	**M**	**Oahu**	**2.18.2011**	
RB02	**11660**	**Adult**	**M**	**Molokai**	**6.12.2011**	
RW02	**11799**	**S3**	**M**	**Kauai**	**7.13.11**	
T21M	**11813**	**A**	**M**	**Oahu**	**7.15.11**	
R4DI	**11805**	**A**	**M**	**Kauai**	**6.15.11**	
R306	11662	A	M	Molokai	5.31.11	no dive data
RO36	11801	A	M	Molokai	5.31.11	no dive data

Objective 2: Determination of Home ranges, foraging trip characteristics, and dive behavior

Data is downloaded periodically using Google Earth to view the current location and recent movements of the instrumented animals. As of 7/31/2011 six tags were still recording data, analyses had been completed for 9 animals (female: n = 2, male: n = 7), and preliminary analyses had begun for 4 animals (male: n = 4). Most of the seals made regular foraging trips out to sea where they traveled, on average, 26.96 km in 0.64 days (Figures 2 & 3). The mean haul-out duration was 0.29 days with seals spending ~ 40% of their time on land (Table 2).

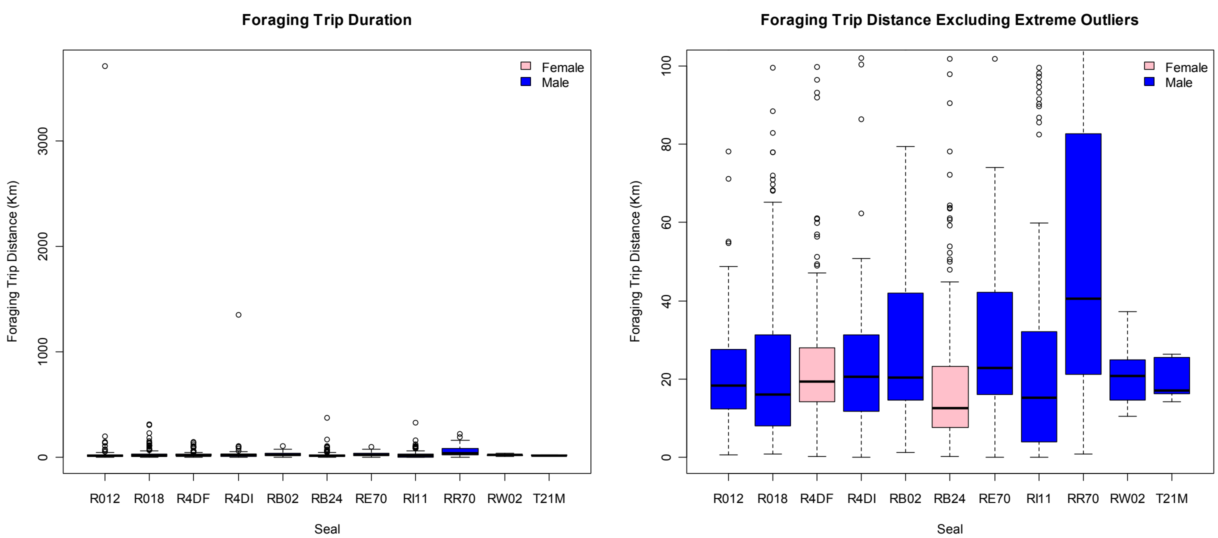


Figure 2: a) Foraging trip distance for monk seals, b) Foraging trip distance for monk seals, excluding extreme outliers.

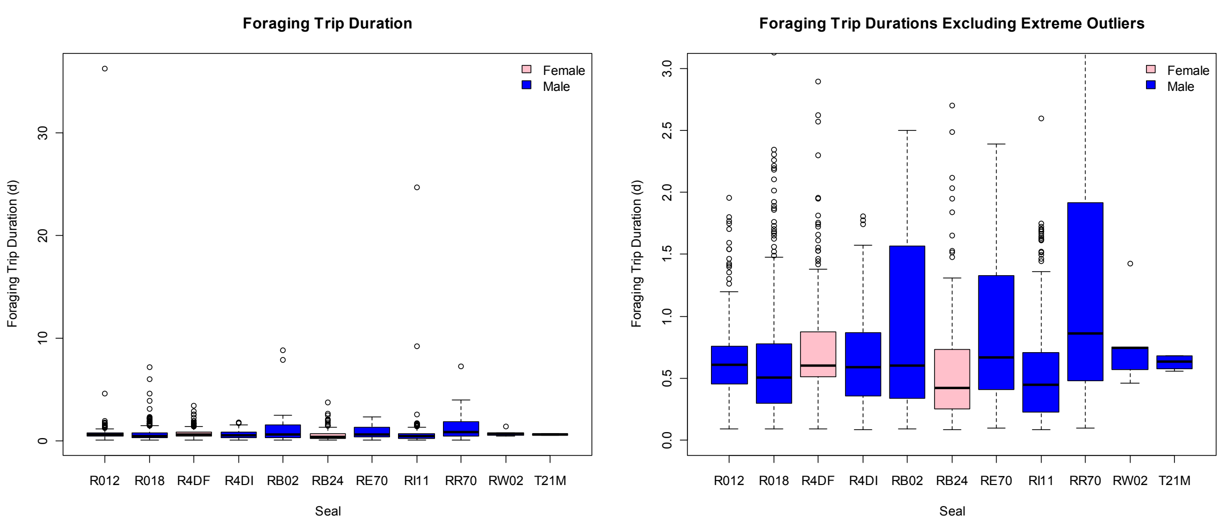


Figure 3: a) Foraging trip durations for monk seals, b) Foraging trip duration for monk seals, excluding extreme outliers.

Table 2. Mean percent of time spent on land for each seal during the tag deployment period.

Seal ID	Age	Sex	Time on Land (%)
R012	A	M	41.00
R018	A	M	38.53
R4DF	A	F	36.68
R4DI	S4	M	40.37
RB02	A	M	40.68
RB24	S4	F	40.54
RE70	A	M	40.15
RI11	A	M	41.15
RR70	A	M	49.01
RW02	S3	M	25.58*
T21M	A	M	38.30*

*These are preliminary numbers for these animals due to only two weeks of data having been collected at the time of writing this report.

Mean foraging trip distance and duration, as well as maximum dive depth are similar between seals (Figures 2, 3, & 4). However, there were multiple outlying data points for all seals which varied by individual (Figures 2 - 5). Excluding R012's extended pelagic foraging trip, none of the seals traveled more than 300 km per trip and most traveled less than 50 km (Figure 2). The mean dive depth was 29.9 m with a maximum of 529 m and a median depth of 12.8 m during the deployment period. The average dive duration was 4.88 min with a median of 4.7 min and 28% of the time spent between dives being spent at the surface. The longest recorded dive was 49.16 min with a maximum depth of 2.4 m indicating that it was likely not a foraging dive.

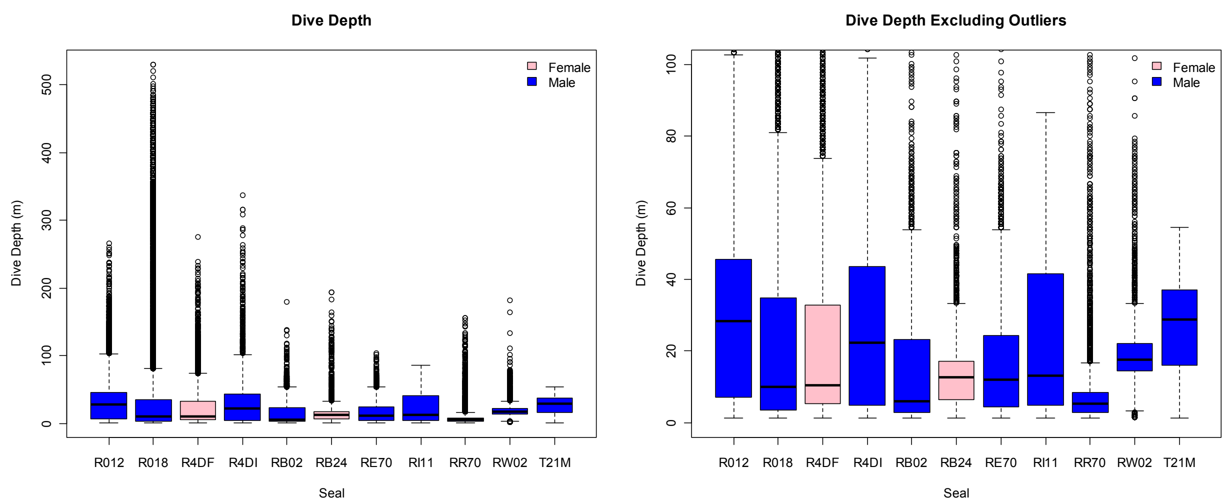


Figure 4: a) Dive depths for monk seals including extreme outliers and b) Monk seal dive depths less than 100 m.

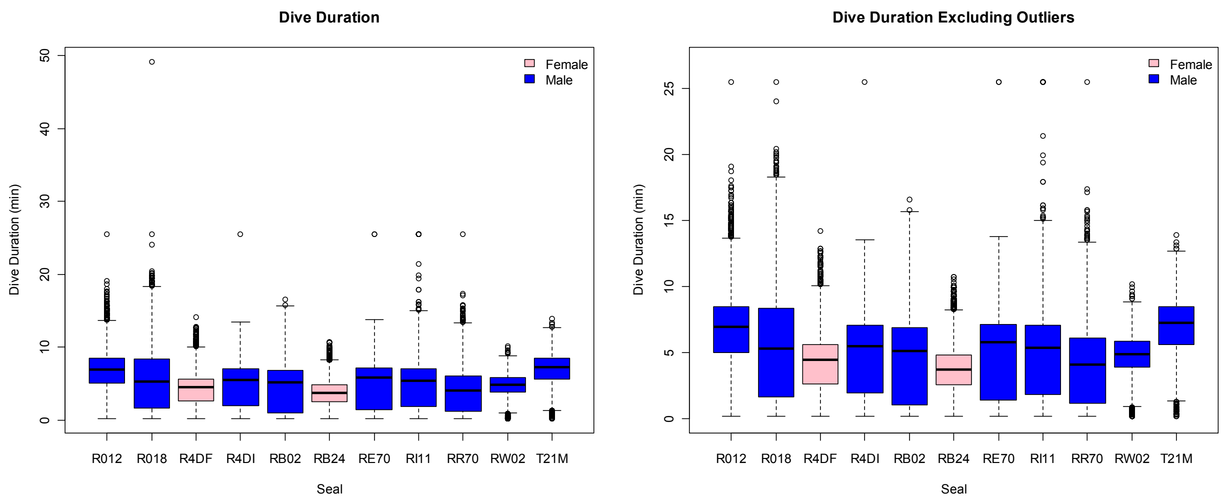


Figure 5. Dive durations for monk seals

The two female seals (R4DF and RB24) had similar dive depths and durations to male seals, but there was less average variation in both the depth and durations of their dives (Figures 4 - 7). Additionally, the maximum depths and durations reached by the females were shallower and shorter than the males (Figures 6 & 7). However, the maximum dive durations for all of the male seals tagged in 2010 were exactly the same (25.5 min), which may indicate some kind of artifact with the data collection or storage within the tag.

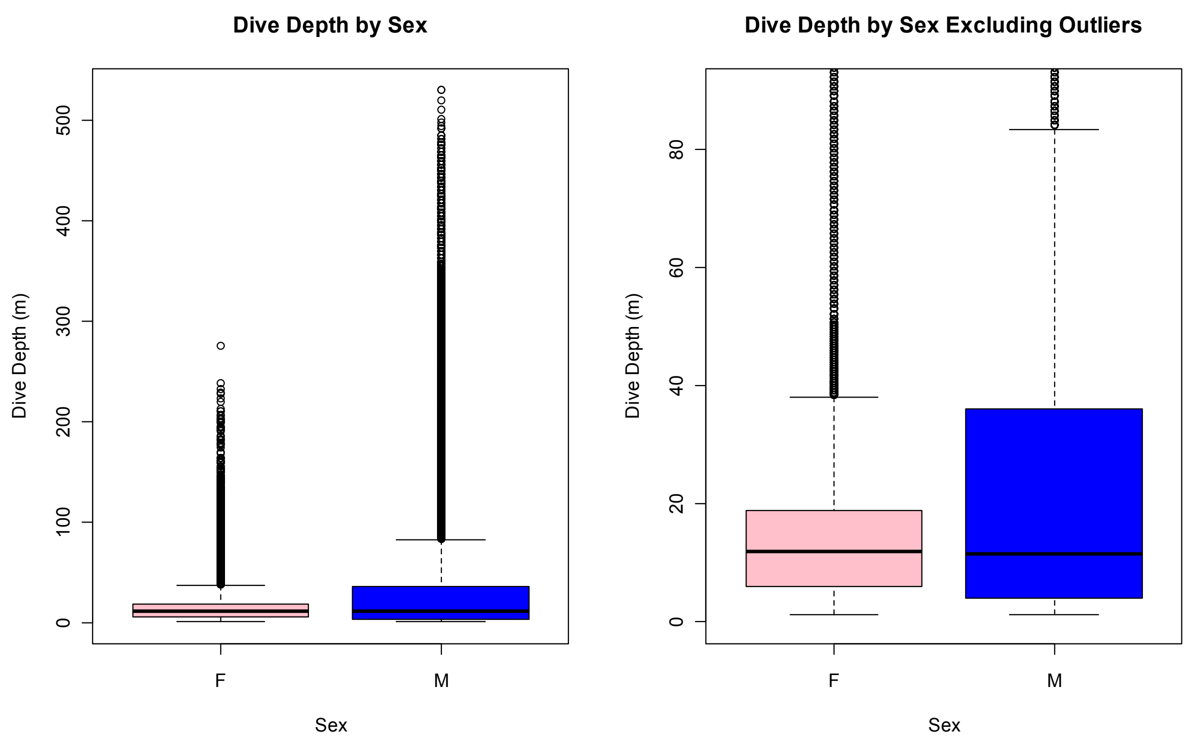


Figure 6. Dive depth relative to sex.

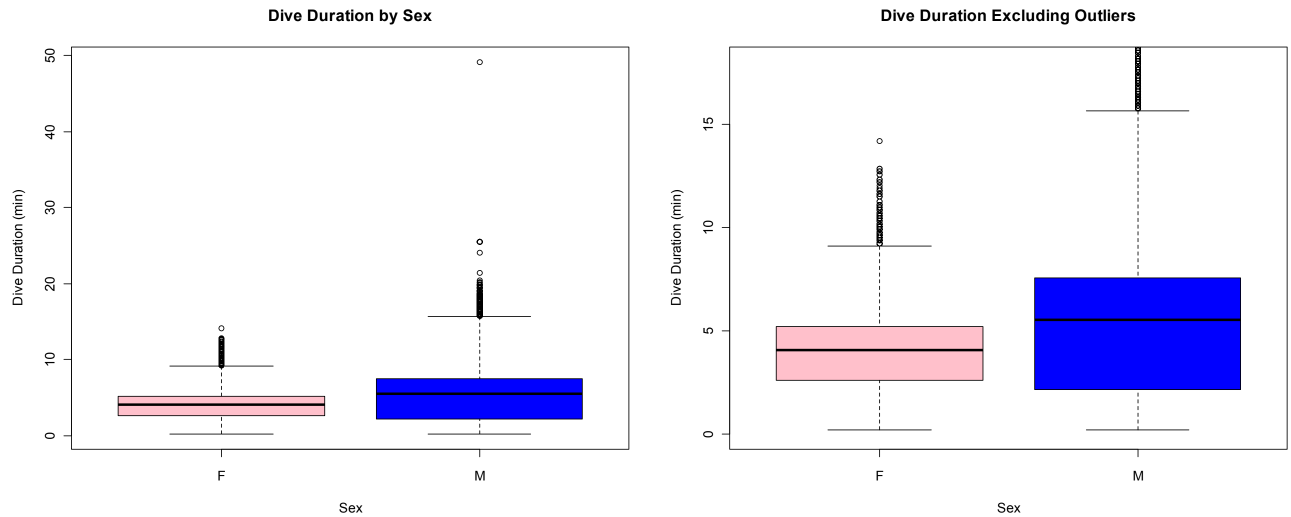


Figure 7. Dive duration relative to sex.

Although foraging trip distances and durations were similar between seals, there was high variability in the space utilized by individuals (Figures 8 – 18). For example, R4DF, a seal tagged on Oahu, traveled from Oahu to Hawaii and spent time foraging near all the islands in between (Figure 8). Conversely, most of the seals tagged on Molokai tended to stay near that island or on Penguin Bank for the duration of tag deployment (Figures 12 & 13). Six of the seals (54%) made regular trips between two or more of the islands, while the remainder showed fidelity to one island. Two seals made at least one long pelagic foraging trip during the deployment period. R012, an adult male tagged on Oahu, traveled over 3,000 km on one trip which lasted 36 days (Figure 8); and RB24, a sub-adult female tagged on Kauai, traveled over 300 km on one trip that lasted almost 4 days (Figure 15). Most of the seals remained within the 600 m depth contour surrounding the MHI and surrounding banks (Figures 8 – 18).

Fixed kernel density home range and core area estimates (utilization density estimates) were calculated for all 11 seals (Table 3). This type of analysis gives the probability of finding an animal in a particular location and also creates contour isolines encompassing areas of equivalent probability. The 95th percentile contour is considered the animal's home range, where there is a 95% probability of finding the animal in that area at any given time; the 50th percentile contour is considered the core area of use, where there is a 50% probability of finding the animal. Utilization densities for monk seals were broken down farther by including a 75th percentile contour, a mid-level between the home range and core area (Figures 8 – 18). Most seals had core areas on one island regardless of their inter-island travels; however, two animals that spent considerable time on multiple islands had segmented core areas that spanned multiple islands (Figures 8 & 11).

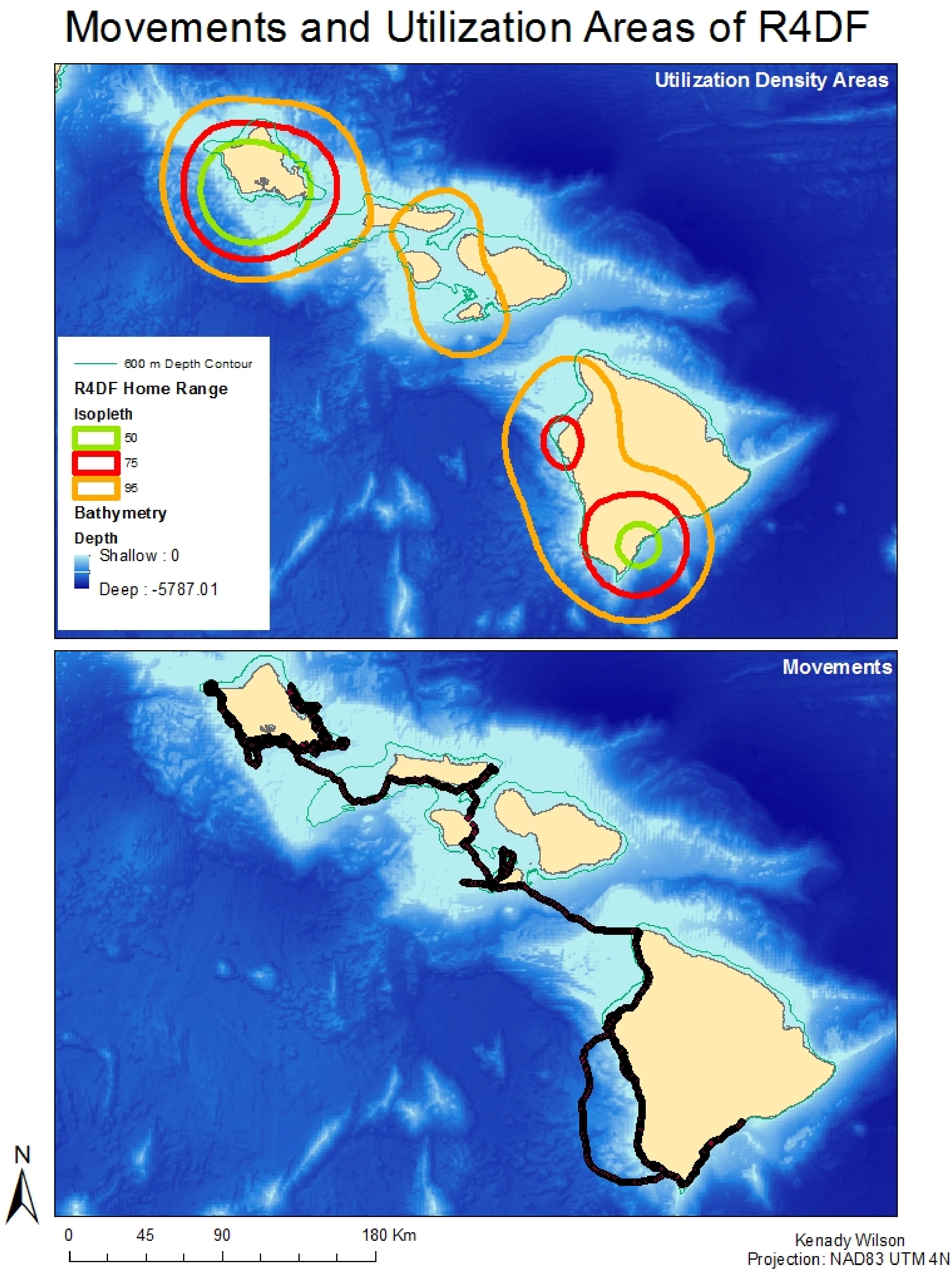


Figure 8. Map of R4DF overall movements and home range areas from July – November 2010

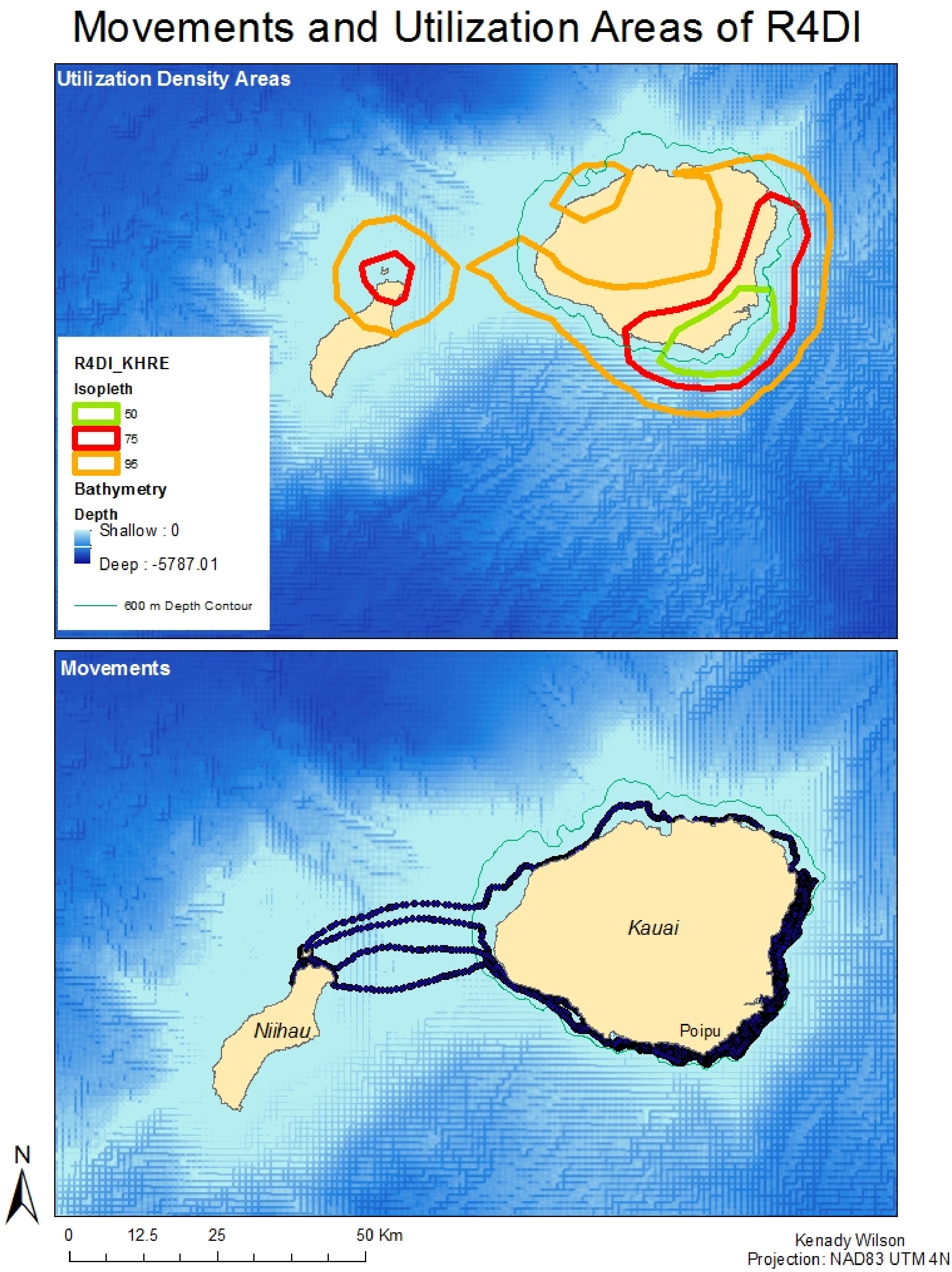


Figure 9. Map of R4DI overall movements and home range areas in February 2010 and June-July 2011.

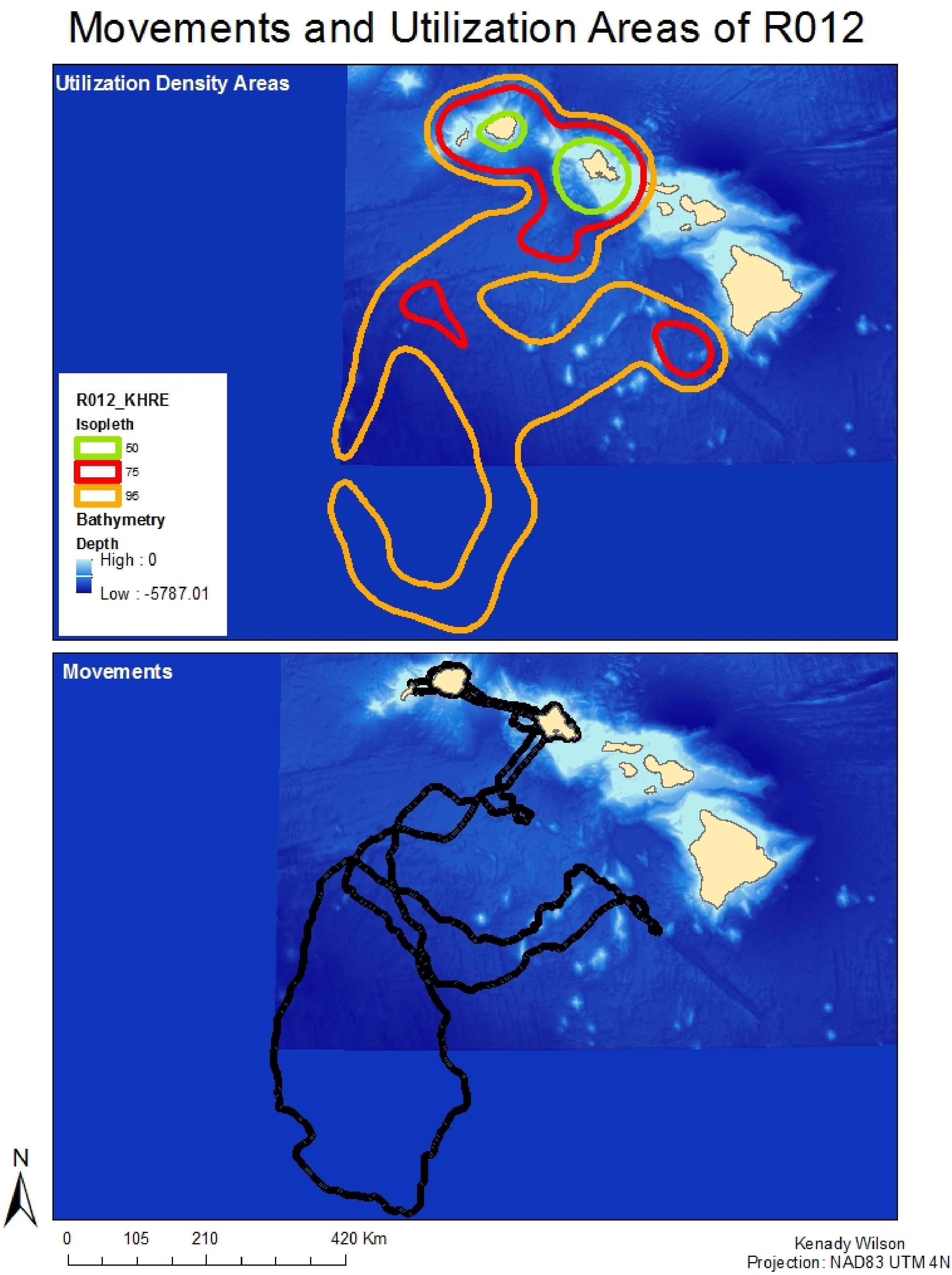


Figure 10. Map of R012 overall movements and home range areas from March – August 2010.

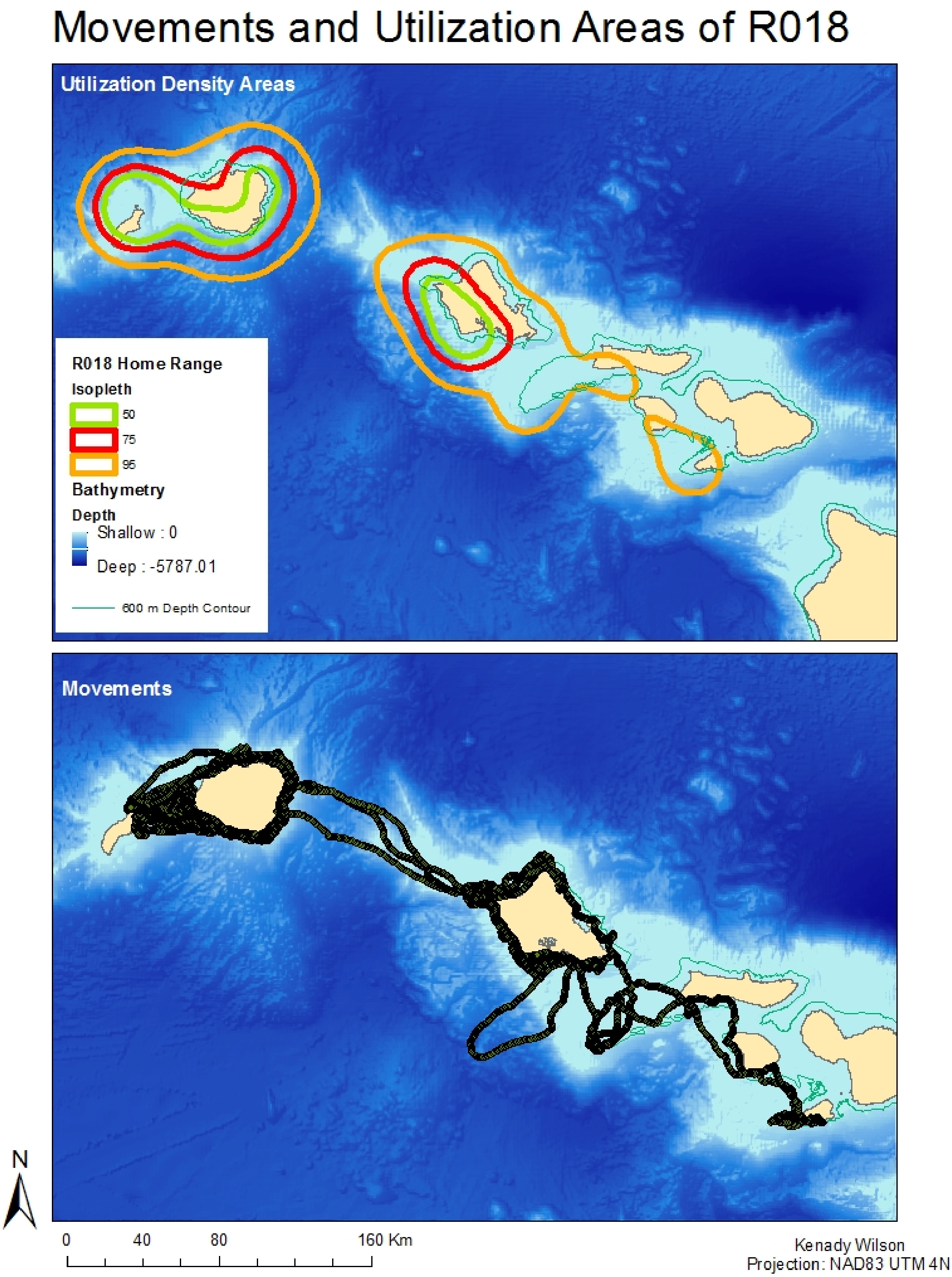


Figure 11. Map of R018 overall movements and home range areas from June – December 2010 and February – June 2011.

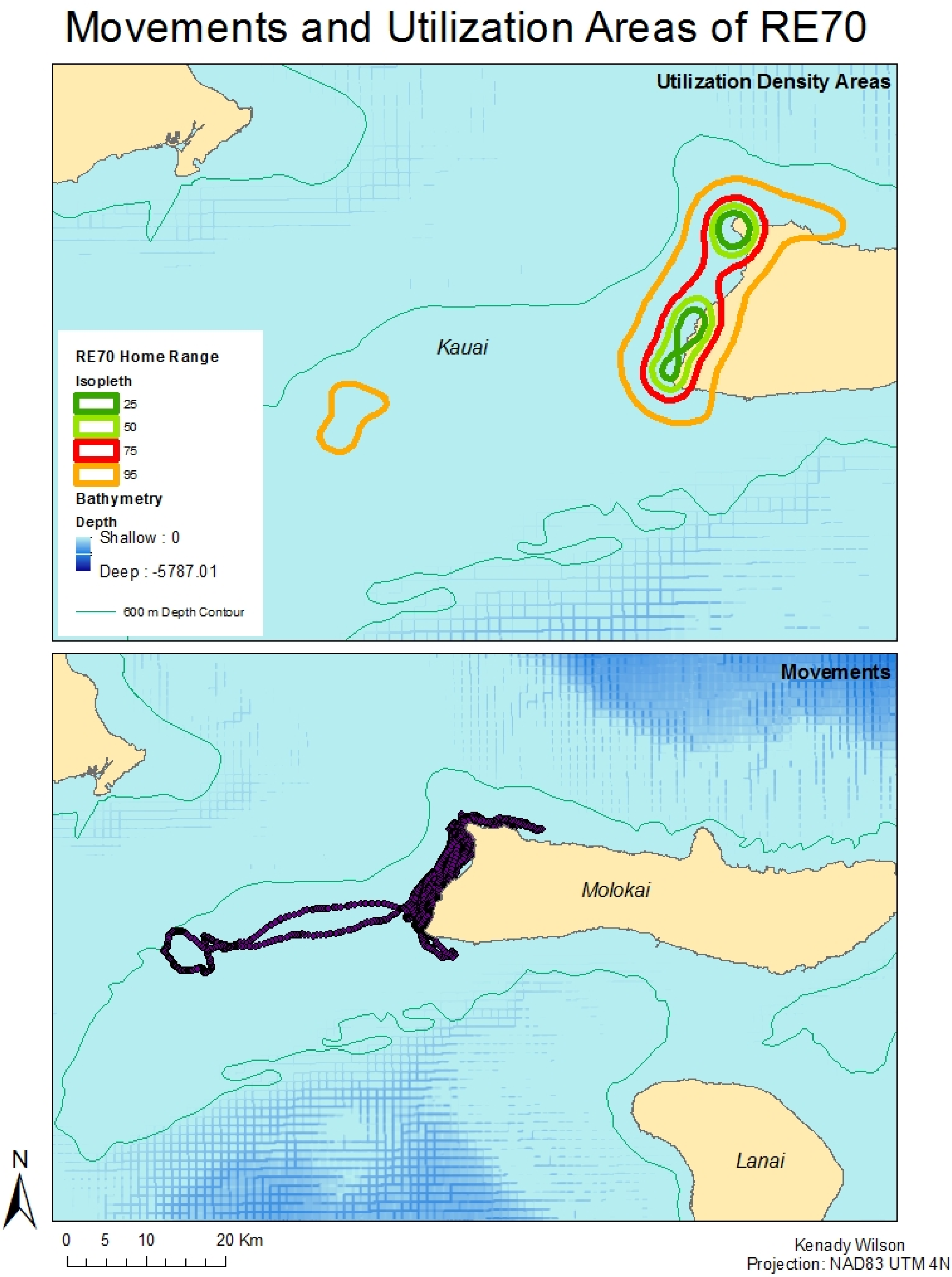


Figure 12. Map of RE70 overall movements and home range areas from March - May 2010.

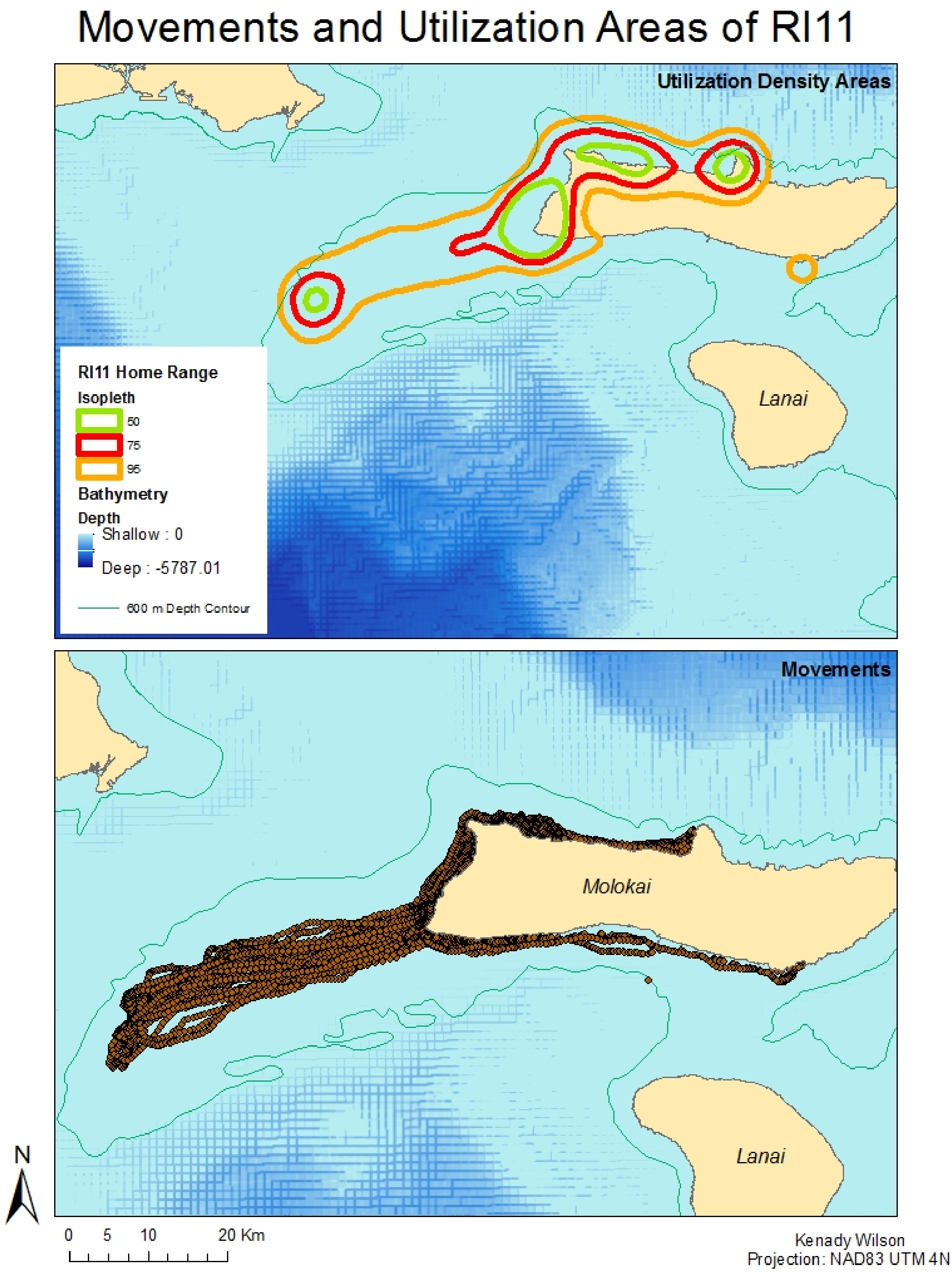


Figure 13. Map of RI11 overall movements and home range areas from March - October 2010.

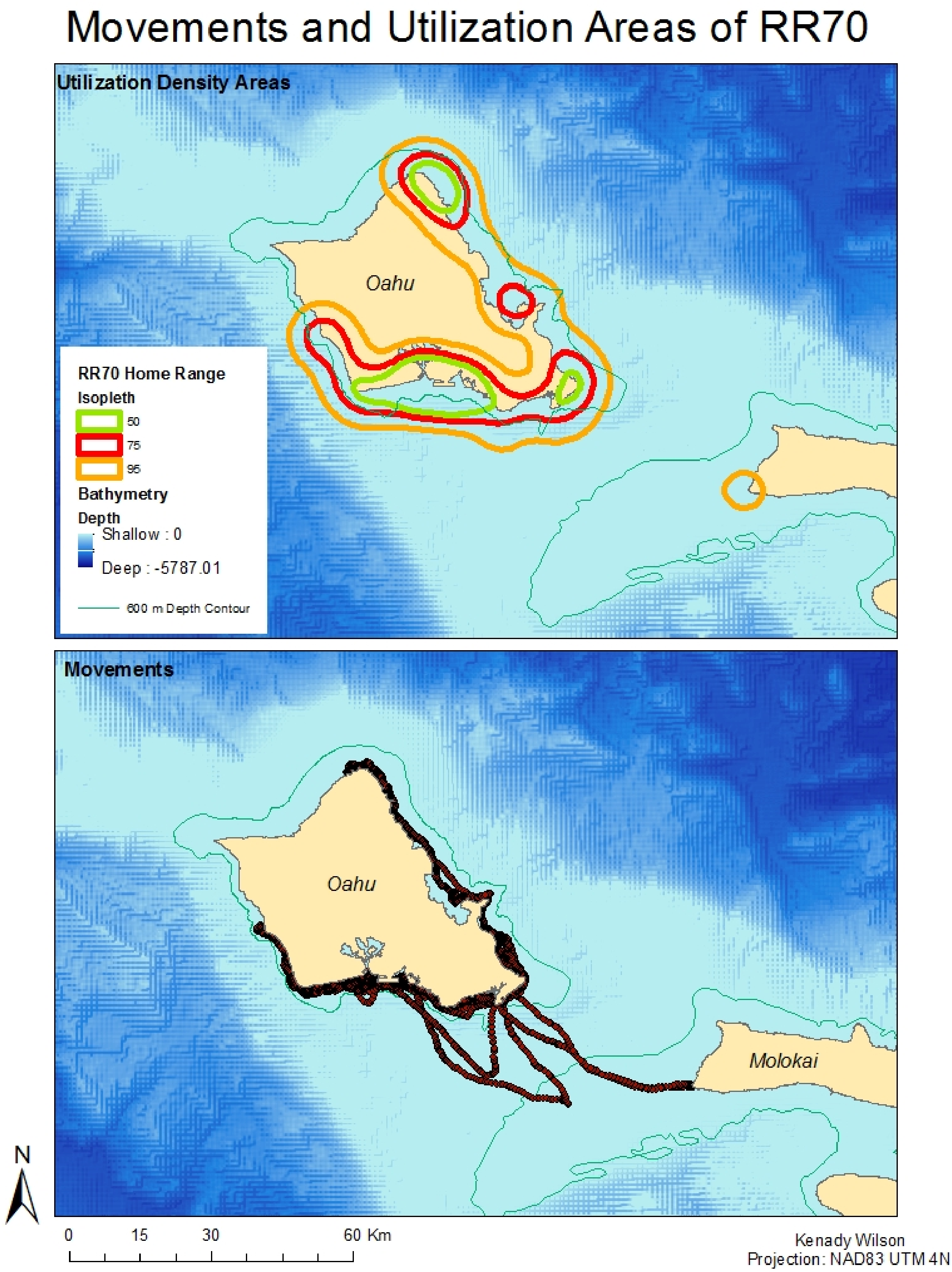


Figure 14. Map of RR70 overall movements and home range areas from June - August 2010.

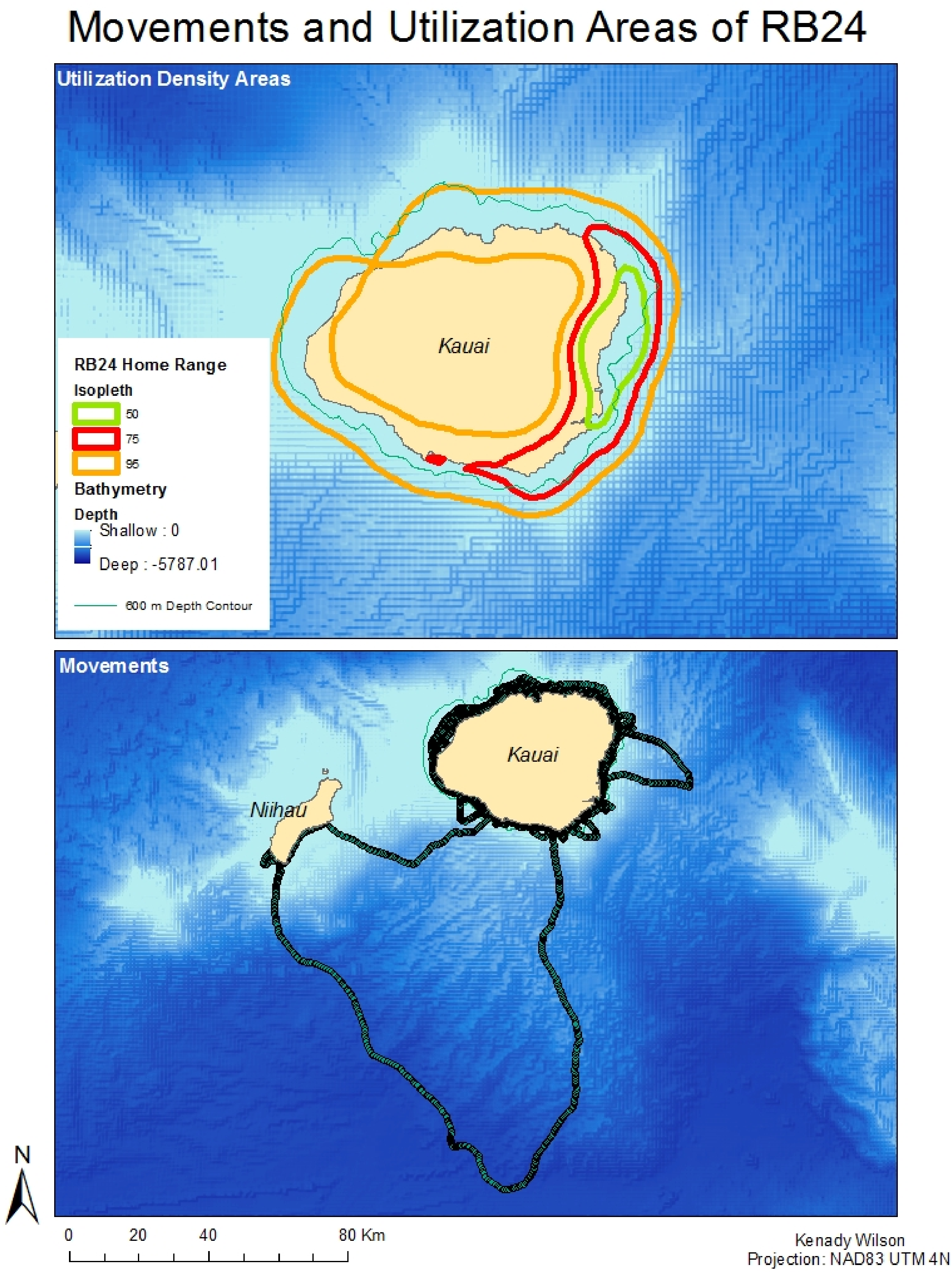


Figure 15. Map of RB24 overall movements and home range areas from January - July 2011.

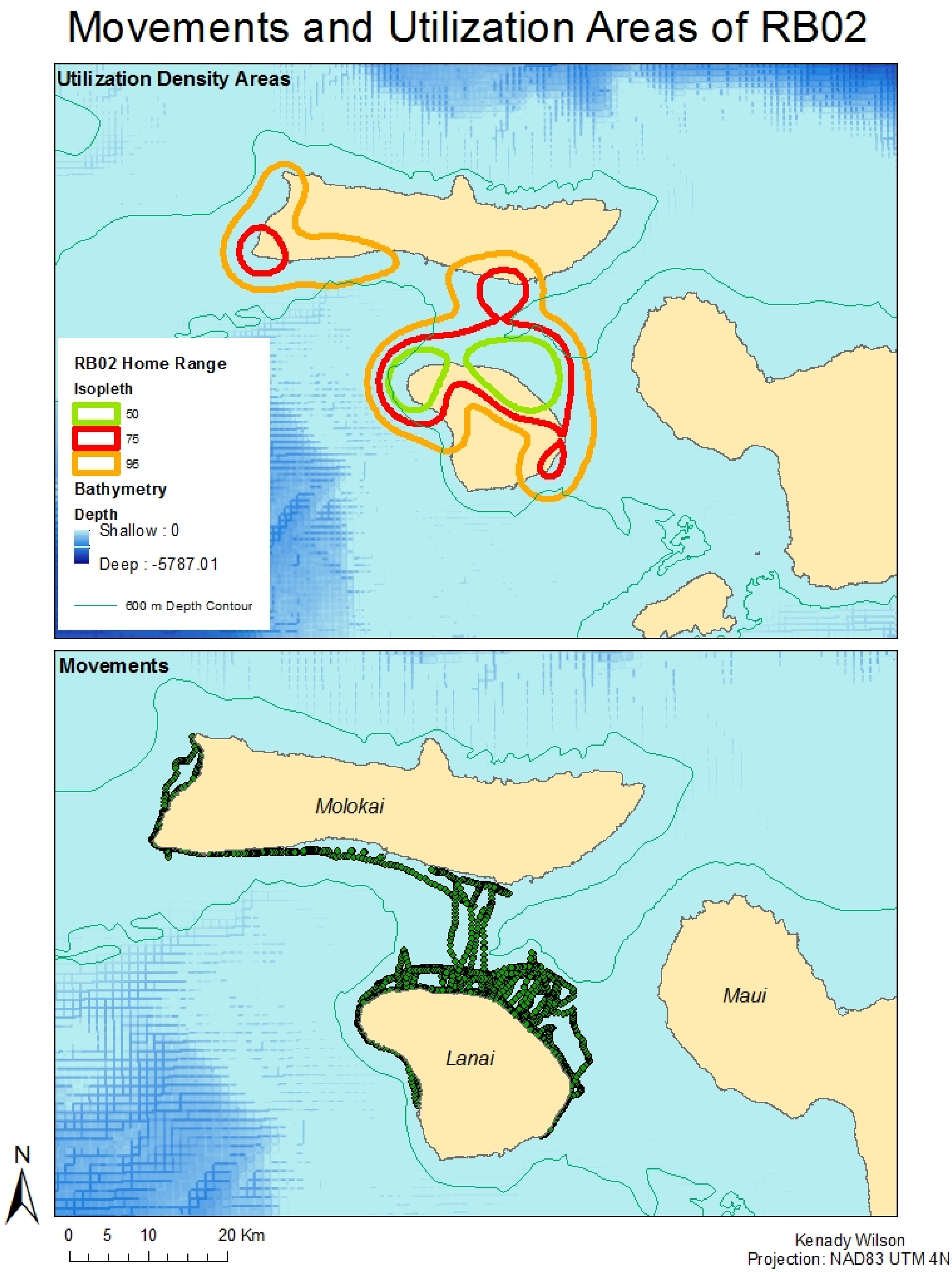


Figure 16. Map of RB02 overall movements and home range areas from June – July 2011.

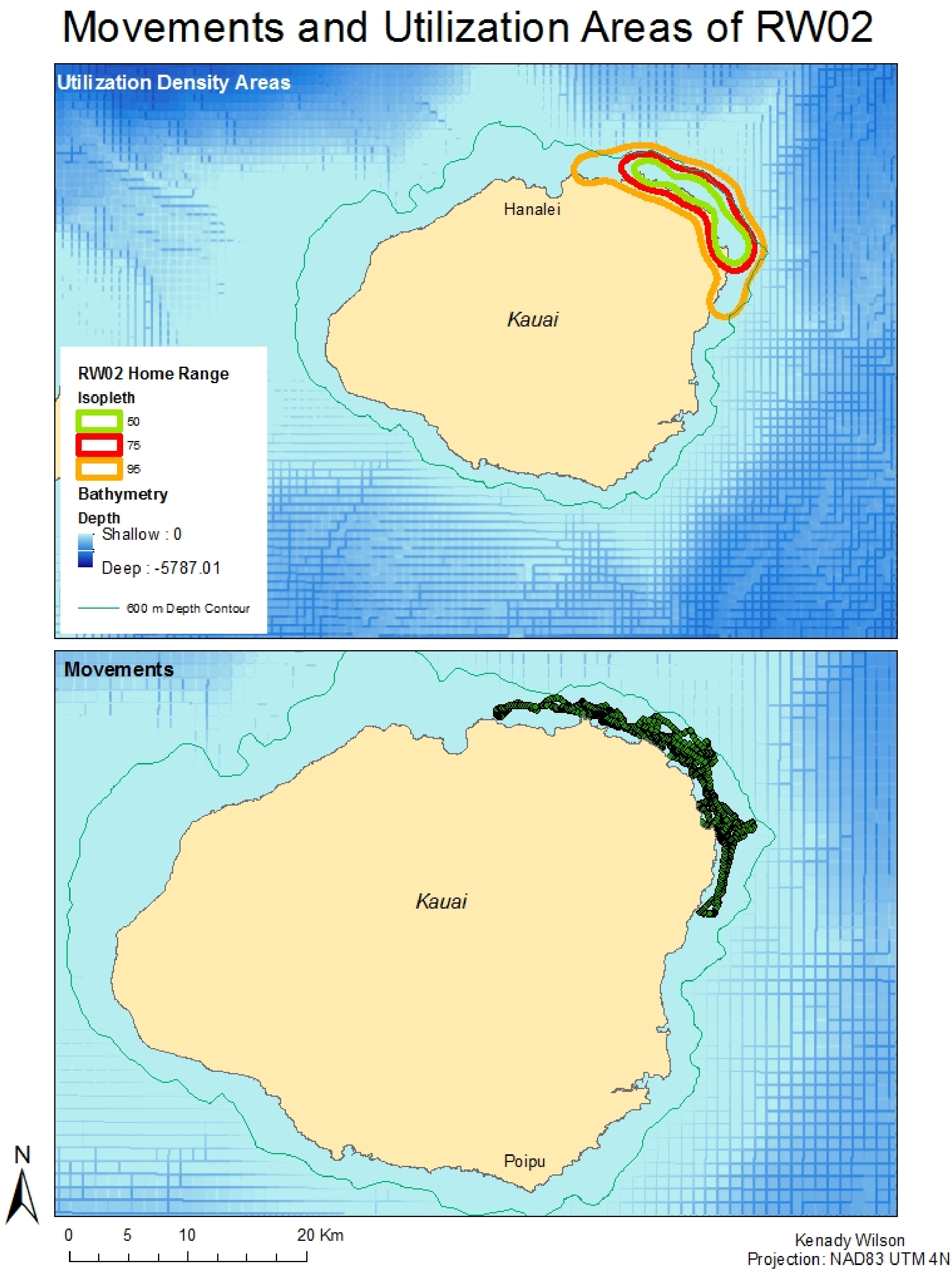


Figure 17. Preliminary map of RW02 movements and home range areas in July 2011.

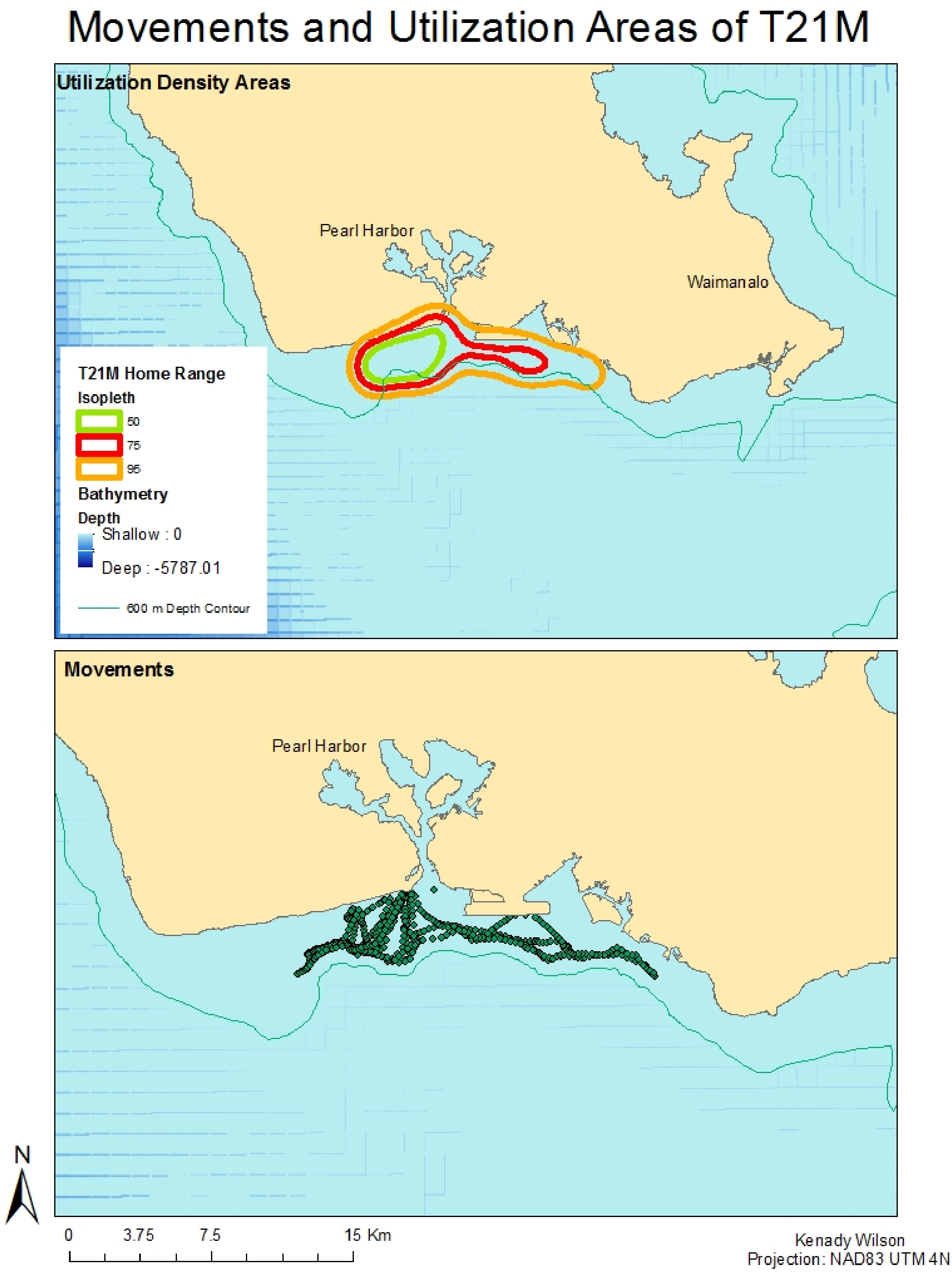
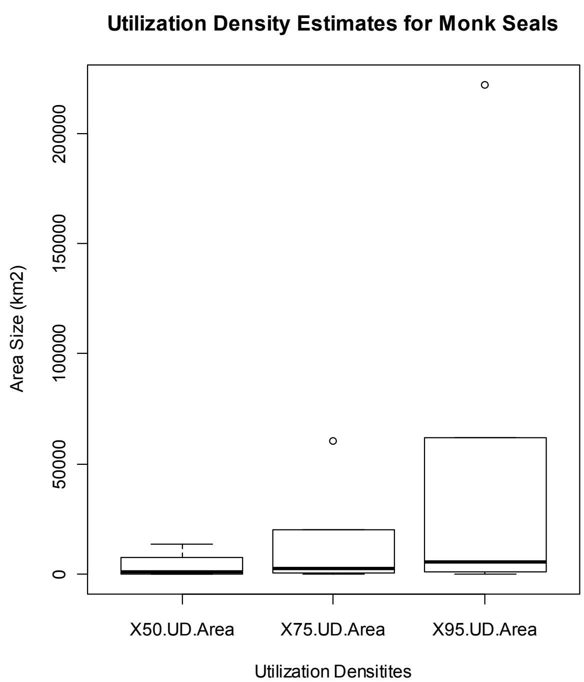


Figure 18. Preliminary map of T21M movements and home range areas in July 2011.

Core area sizes were similar between seals, while home range sizes were more variable (Table 3, Figure 19). The variable home range sizes are likely due to the increased area traveled by some animals (R4DF & RO18) and the pelagic foraging trip of R012.

Table 3. Utilization density estimates of home range (95%), core area (50%), and mid-level area (75%) sizes.

SealID	Age	Sex	# Locations Used	50% UD (km^2)	75% Area (km^2)	95% Area (km^2)
R012	A	M	19827	13708.65	60304.19	222038.5
R018	A	M	36945	4109.261	8782.538	22708.37
R4DF	A	F	23849	7572.84	20486.52	62814.71
R4DI	S4	M	7711	303.7034	780.9517	2516.4
RB02	A	M	4797	206.0989	525.2296	1240.893
RB24	S4	F	30903	153.4154	468.8894	1540.636
RE70	A	M	6892	31.6168	67.35753	190.8463
RI11	A	M	25244	167.665	439.6378	1061.621
RR70	A	M	12052	328.2178	806.9396	1923.39
RW02	S3	M	1711	43.28034	87.26405	186.0164
T21M	A	M	831	18.05877	44.63046	97.45327



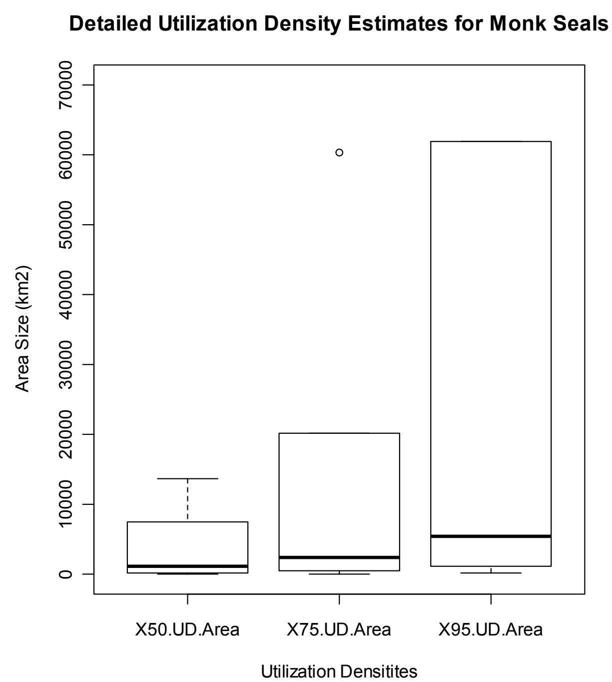


Figure 19. Fixed kernel density estimates for monk seal home ranges and core areas

In the future these home range calculations will be compared to the home ranges and core areas that are calculated via mechanistic home range models, which provide a more detailed understanding of animal movement and habitat use, by incorporating stochastic processes into the model.

Objective 3: Identify potential changes in monk seal behavior

Analyses to correlate monk seal behavior and Navy training activities in the MHI will begin once all tags have ceased transmission or been recovered. These analyses will include calculating the amount of time each seal spent within the HRC during tag deployment, and incorporating Navy activities into a mechanistic home range model of monk seal movement behavior and habitat use.

A meeting between researchers and Navy personnel to discuss data and analysis techniques is tentatively scheduled to occur in 2011.

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Appendix 1. Highlights of select foraging trips for seals tagged in 2010

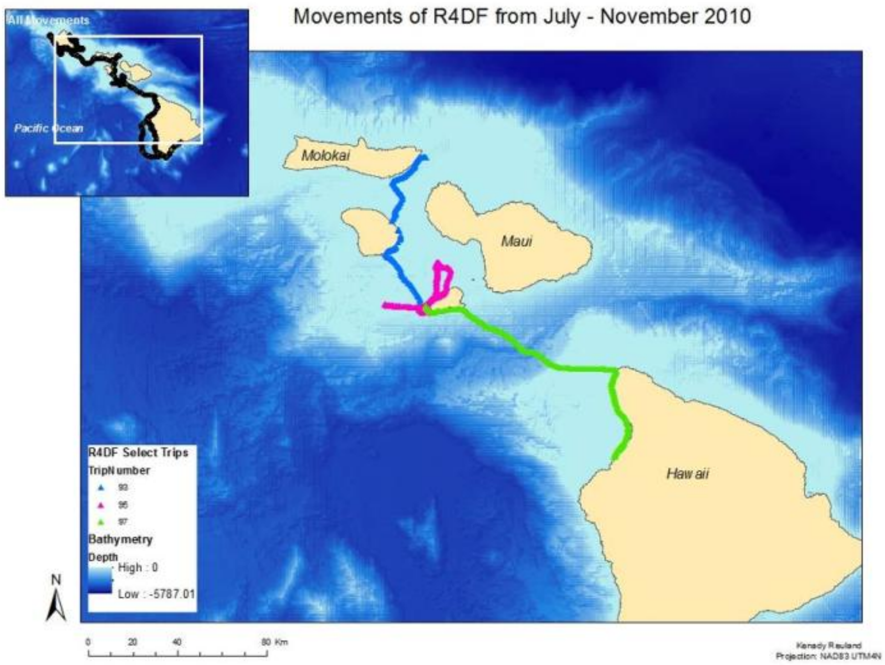

Figure 1. Map of R4DF overall movements with tracks highlighted for select foraging trips

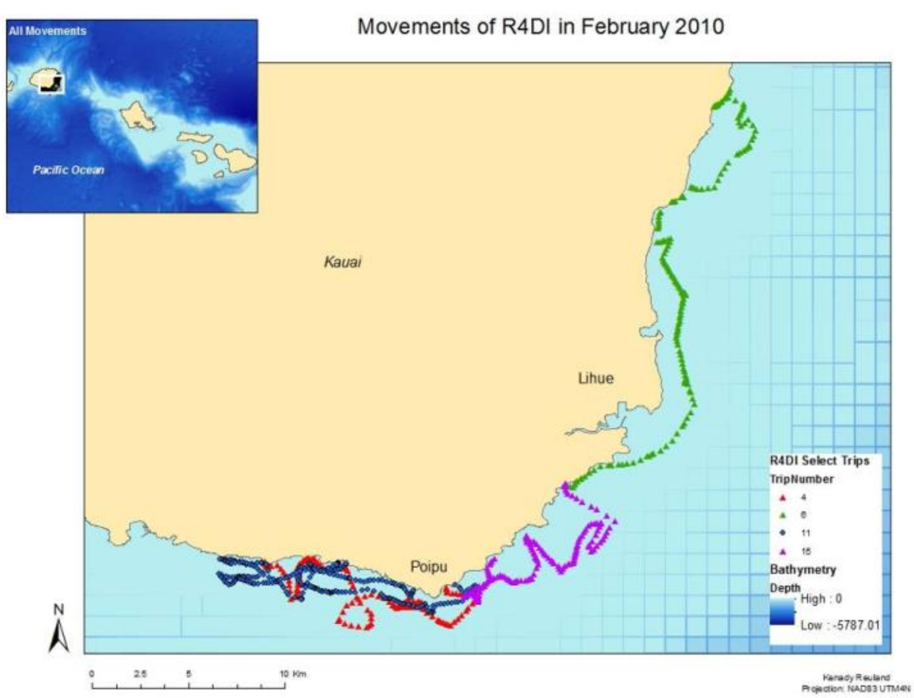

Figure 2. Map of R4DI overall movements with tracks highlighted for select foraging trips

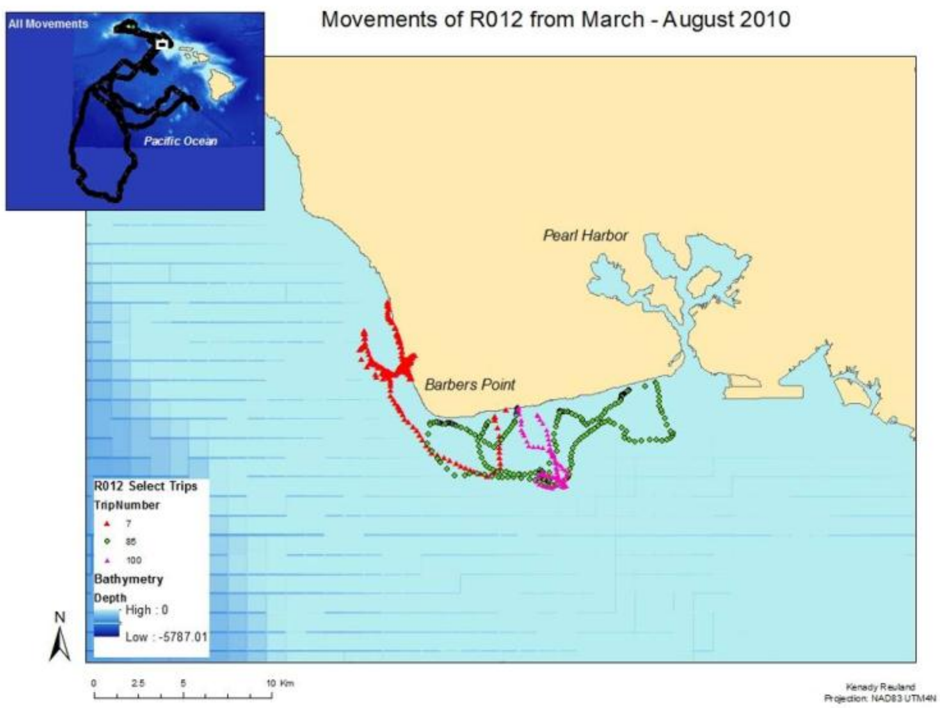

Figure 3. Map of R012 overall movements with tracks highlighted for select foraging trips

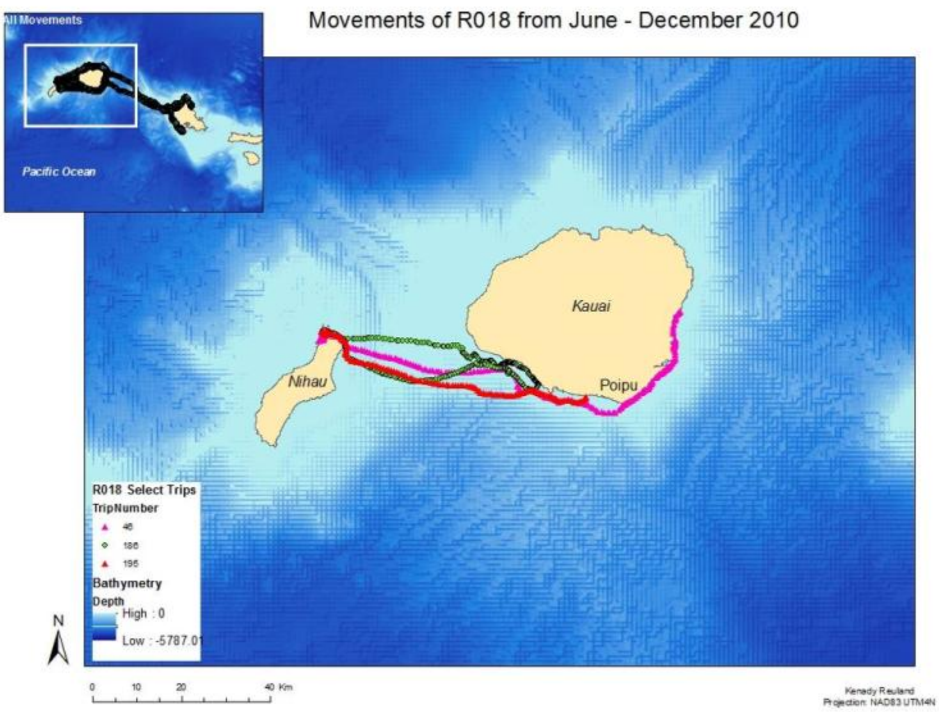

Figure 4. Map of R018 overall movements with tracks highlighted for select foraging trips

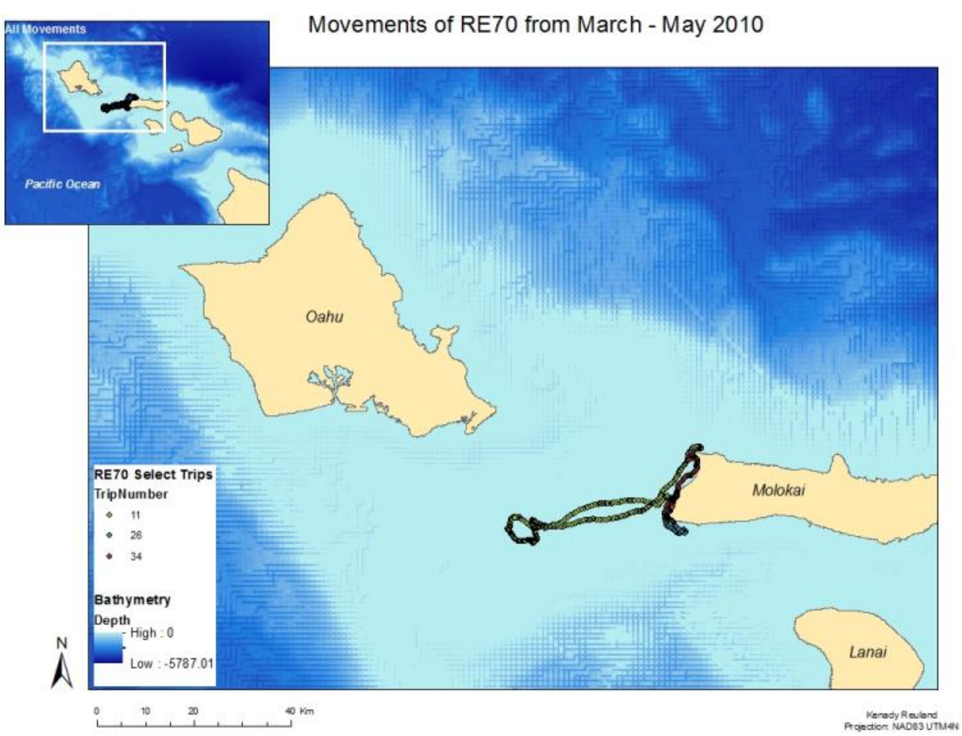

Figure 5. Map of RE70 overall movements with tracks highlighted for select foraging trips

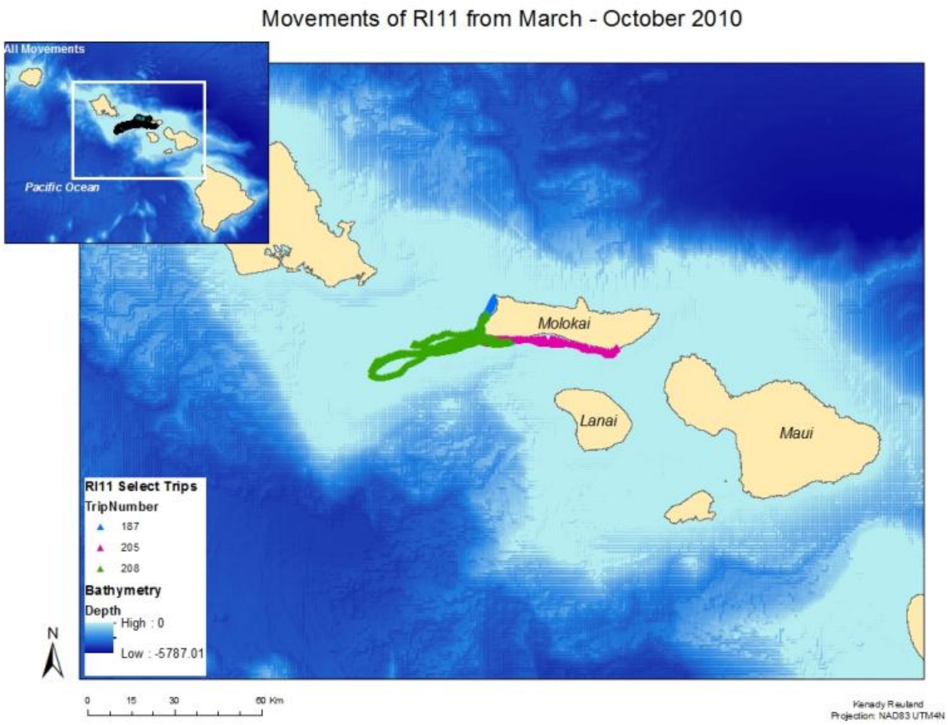

Figure 6. Map of RI11 overall movements with tracks highlighted for select foraging trips

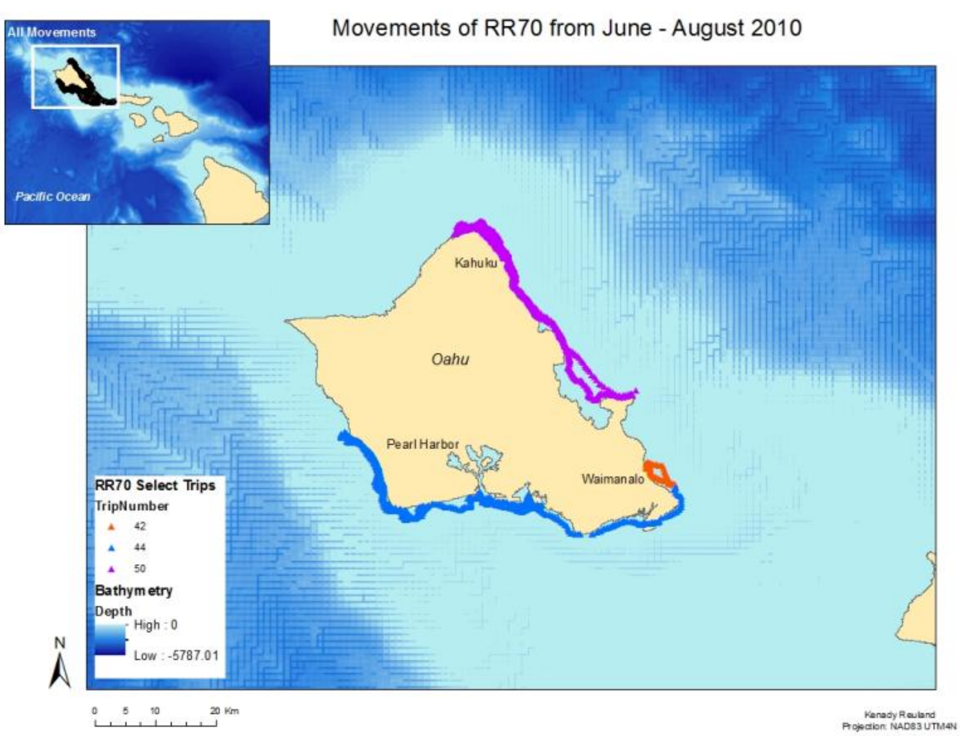

Figure 7. Map of RR70 overall movements with tracks highlighted for select foraging trips

APPENDIX N. Report on Analysis for Marine Mammals Before, During and After the Feb 2011 Submarine Commanders Course Training Exercise.

Prepared 08 Sept 2011 by Stephen W. Martin, SPAWAR Systems Center Pacific, Code 71510 and Thomas Kok, San Diego State University Foundation

This report provides information relative to marine mammals at the Pacific Missile Range Facility (PMRF) before, during and after the Feb 2011 Submarine Commanders Course exercise (SCC) between 11 and 22 Feb 2011. This is the first instance of having acoustic data available during an SCC which allows expanded analysis (such as estimating exposure levels on animals) compared to the report done for the Feb 2010 SCC exercise (Martin 2010).

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

Sound pressure levels (SPL's) that marine mammals were exposed to from a US Navy destroyer (DDG) equipped with the AN/SQS-53C sonar transmitting nominal 3kHz MFA pulses are estimated using sonar equations and a ray trace propagation model in post-processing of recorded passive acoustic data for a focus period between 05:58 and 07:39 HST on 17 Feb 2011. Exposure levels are estimated for three separate DDG 3k MFA transmissions at 06:17, 07:35 and 07:38 for a minke whale, a humpback whale and a group of unidentified whales respectively. Results show the highest estimated exposure level of 164 dB SPL re micro Pascal (μPa) was for the group of 3 to 5 unidentified whales that were sighted at 07:39 by observers on the DDG (sighting #9) which were at a distance of 3.4km from the DDG at 07:38. A minke whale was acoustically automatically detected, classified and localized from early morning 17 Feb through 10am, manual validation determined that a total of 15 boing calls were produced between 5:58 and 07:36 and position estimates refined using corrected times of arrival. The minke was exposed to an estimated SPL of 139 to 145dB re μPa at 06:17 at a distance of 16.3km which would be the strongest on this animal as the distance with the DDG opened for the remainder of the event. The minke whale did not seem to significantly change its swim behavior or vocal pattern. A single, manually derived, acoustic localization for a humpback whale at 07:36 was 21 km from the DDG and exposed to a SPL of between 136 to 141 dB re μPa. The range of SPL's is related to the type of propagation path (direct, ducted or bottom bounce) and model used for the estimate.

Analysis of sound pressure levels animals were exposed to for additional focus periods in this exercise are planned using a standard US Navy propagation model (PCIMAT). This exercise provides many opportunities for estimating exposure levels on animals with potential for observing behavioral changes. Analysis of visual sighting # 14 is underway as it was specifically commented on in the cruise report (Farak et al. 2011) due to the animals close proximity to the DDG and multiple sightings at close range.

Introduction

This is the first instance of having acoustic data available for marine mammal monitoring during a US Navy exercise at PMRF, specifically during the 14 – 19 Feb 2011 SCC. This report focuses on sonar exposure to marine mammals between 06:17 and 07:38 on 17 Feb 2011 which covers the period of active 3kHz (nominal) MFA transmissions during the event termed "miniwar III". This event involved three surface ships transmitting MFA signals and one submarine. This effort focuses on the 3kHz MFA (3k MFA) transmissions from the US Navy destroyer (DDG) equipped with the AN/SQS-53C sonar system. The other two surface ships were employing higher frequency mid frequency sonar signals which are not addressed in this report.

The focus time was selected for multiple reasons: 1) to limit the analysis to a manageable effort for understanding what types of information in relationship to exposure levels are available; 2) a sighting was made during the period of MFA activity; 3) acoustic analysis indicates high confidence locations for a minke whale (Balaenoptera acutorostrata) on range during MFA activity; and 4) acoustic analysis also indicates humpback whale (Megaptera novaeangliae) presence on the range during MFA activity.

There was also a visual sighting of an individual humpback whale from trained marine mammal observers aboard an aircraft nearby at 08:10:58. Exposures were not estimated for this sighting due to animal location uncertainty over 30 min from the last 3k MFA transmission.

This effort utilizes sonar analysis employing both a ray trace model and sonar equations to estimate the sound pressure level expected at the animal locations. The use of PMRF bottom hydrophones in validating the exposure level estimations is also described.

Analysis of automated minke and beaked whale signals is performed in a manner similar to that reported for the before and after portions of the Feb 2010 SCC exercise (Martin 2010). The analysis shows presence of these species before, during and after the Feb 2011 exercise. Manual analysis for other species is also provided.

Methods

The method utilized to estimate the sound pressure level animals are exposed to require animal and surface ship locations very close in time to MFA transmissions. Ship positions are obtained from standard PMRF exercise products. Animal locations are determined by sightings and processing of recorded passive acoustic data. Two models are utilized to estimate the sound pressure levels at animal locations; sonar equations and a ray trace program. The acoustic data was also utilized to confirm precise 3k MFA transmission times and to compare with model outputs. The ray trace program (Ray Trace ver. 1.1.1 dated 08-04-2005) was developed by Roy Deveanport, with modifications by F. Ludecke, at the Naval Undersea Warfare Center (NUWC). This ray trace program has only been validated for horizontal ranges up to 10km and does not include bottom reflection losses. Standard US Navy models, such as PCIMAT, are planned to be used in future analysis. A sound velocity profile (SVP) for measured data from 27 April 2009 to 750m depth combined with historical data to the seafloor was utilized. This SVP does show a viable surface duct path. Future efforts should obtain in-situ SVP data.

Parameters and assumptions employed in this analysis, and their nomenclature, are: a 3kHz nominal frequency (f=3); a source level (SL) of 235dB re µPa; absorption coefficient at 3kHz (α) of 0.2 dB per km (Ilyina 2009); a sonar source depth (d) of 5m; animal depths of 10m (ad) ; a surface duct of 50m (H); a sea state (S) of level 2; sonar projections towards animals are at the surface ship sonars maximum response axis (MRA) except as otherwise noted. The environment is deep water environment with viable surface duct and bottom reflection propagation paths. For short range direct path propagation assumes spherical spreading including the absorption coefficient contribution. The surface duct path cannot be validated with PMRF bottom phone data in this analysis; however the validity of the bottom multipath is confirmed with data from the PMRF range hydrophones.

The surface duct (or mixed layer duct) propagation path sonar equation includes transmission loss from spherical spreading, cylindrical spreading, and attenuation coefficients for both normal propagation and duct leakage. The equation appears in Urick's 1983 book, Principles of Underwater sound and is provided as equation 1 where Le is the estimated sound pressure level of the exposure:

$$\text{Equation 1:}\quad Le = SL - (10*\log10(ro) + 10*\log10(r) + 0.001*r\,(\alpha + \alpha L))\ \text{in (dB)}$$

where: SL is the source level; ro is the transition range (m) from spherical to cylindrical propagation and for this case is estimated as 2568 m (from H/0.3048*sqrt((R/.3048) / (8*(H/.3048-d/03048))) where R is the radius of curvature of the surface duct rays (~ 88,235 m); r = range from source to animal (m); α is the attenuation coefficient (0.2dB/km for 3kHz) and αL is the surface duct leakage coefficient in dB/km and is estimated (Urick 1983) as 2/0.9144*S*sqrt(f*0.3048/H) where f is in kHz. Substituting these parameters and values into equation 1 results in:

$$\text{Equation 2: } Le = 200.9 - 10*\log10(r) - 0.001*r*(0.2+0.5916))$$

The surface duct transmission loss is seen to have major contributions from the surface duct leakage component (αL) and the transition range from spherical to cylindrical spreading (ro).

Data for the surface ship (DDG) marine mammal observers sighting at 07:39 is derived from Farak et al. 2011 (the cruise report). The sighting was geo-referenced using the sighting data with ship position at the time of the sighting and a ship heading derived from PMRF standard exercise products. The sighting was of unidentified whales, in a group of from 3 to 5, with report of "at least 3 bushy angled blows likely due to humpback or sperm whales".

The bottom bounce path sonar equation model assumes spherical spreading, constant sound speed profile, a nominal 7dB bottom reflection loss (BRL) for grazing angles from 25 degrees to 70 degrees, a flat bottom depth of 4550m and that d (source depth in m) is << wd (water depth in meters) and that ad (animal depth in m) is also << wd. Equation 3 provides the estimated exposure sound pressure level for the bottom propagation path. Notice their is no correction for the relative heading from the DDG to the animal being significantly off the AN/SQS-53C maximum response azimuth and elevation angles. This is a source of significant error for certain geometries, but is not quantitatively addressed for security reasons in this report.

$$\text{Equation 3: } Le = SL - 20*\log10(sr) - sr*0.001*\alpha - BRL$$

Where BRL is the bottom reflection loss (7dB for grazing angles from 25 to 70 degrees) and sr is a first order estimate of the path slant range between the DDG and animal and is given by simple geometry as sr ~ 2*sqrt(wd2 + r2/4).

Results

Acoustic data collection

Thirty one hydrophones of passive acoustic data was collected continuously (with one 8.5 hr exception) for approximately 257 hrs between Friday 11 Feb 2011 @ 08:20 HST and Tuesday 22 Feb@ 10:32 HST. Figure 1 shows a plot of the approximate location of the range hydrophones recorded for this effort. The northern eighteen BSURE (Barking Sands Underwater Range Expansion) hydrophones analyzed in 2010 were replaced with 41 wider bandwidth (~50Hz to 45kHz) hydrophones early in calendar year 2011 (of which 18 were recorded in lieu of the previous 18 hydrophones). Acoustic data was recorded onto four 3.5" SATA hard drives as files of approximately 10 minutes duration with file name convention shown in table 1. The torpedo exercises (three events) were scheduled to start at 00:00 on Monday 14 Feb 2011 and complete Wed 16 Feb 2011 @ 02:00, while the miniwar exercises were scheduled to begin Wed 16 Feb 2011 @ 05:00 and complete Sat 19 Feb 2011 @ 03:00.

Table 1 – Acoustic data recordings dates, times, filenames, exercise events and number of hours of multiple channel (31 phones) data.

HST date/ start time	HST date / end time	File names	events	# hrs
Fri 11 Feb 2011 08:21	Mon 14 Feb 2011 01:54	11Feb11_182158_001 to 394	Pre exercise & start of torpex I	65.6
Mon 14 Feb 2011 10:02	Wed 16 Feb 2011 13:55	14Feb11_200233_001 to 312	Torpex I,II,III & Miniwar I	52
Wed 16 Feb 2011 13:57	Sat 19 Feb 2011 03:41	16Feb11_235737_001 to 370	Miniwar I - VI	61.6
Sat 19 Feb 2011 03:41	Tues 22 Feb 2011 10:32	19Feb11_134154_001 to 475	Post exercise	79

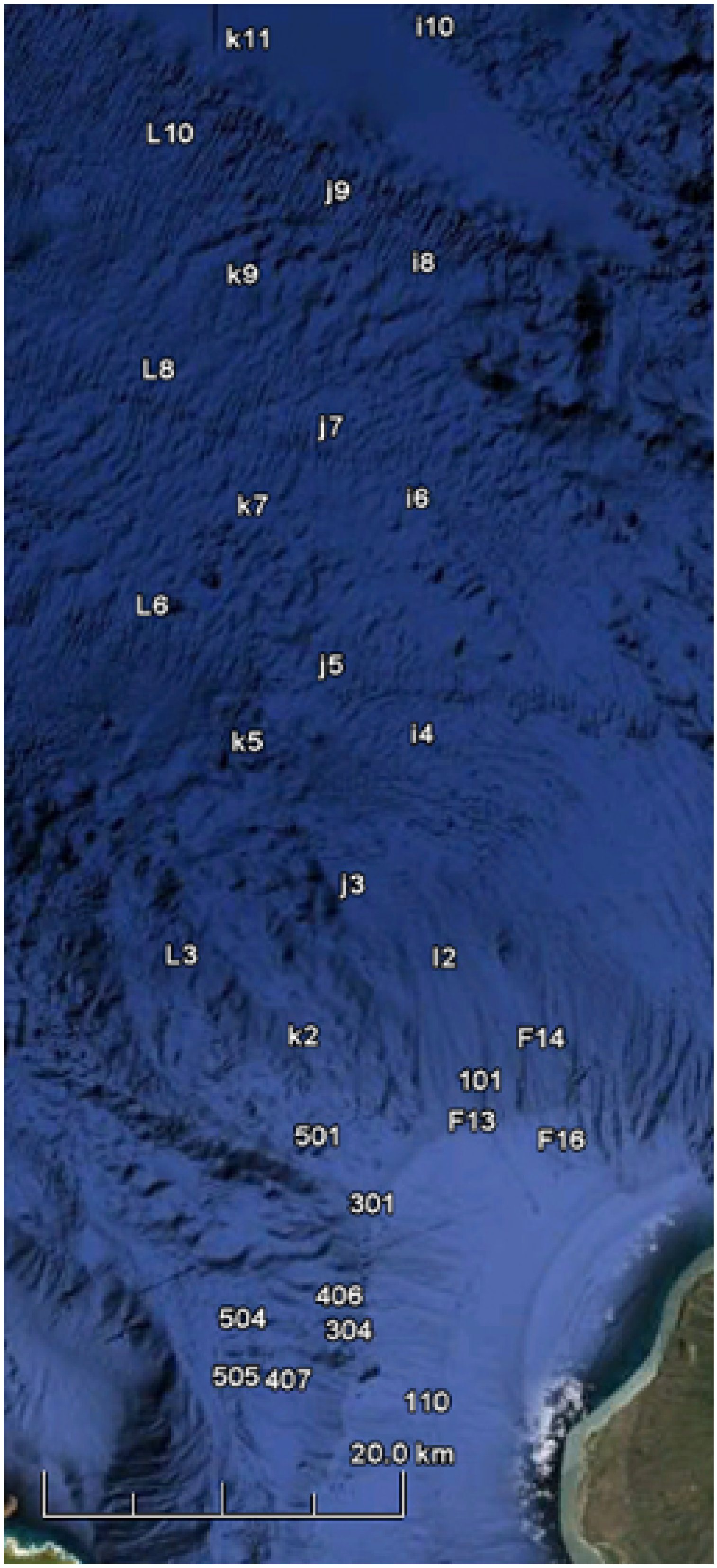

Figure 1 – Thirty-one hydrophones recorded and utilized in the analysis. Kauai lower right.

The newly installed hydrophones (with I, J, K, and L first characters in their nomenclature in figure 1) provide a higher frequency response compared to the old hydrophones (45kHz vs. previous 19kHz) which enables detection of higher frequency calls / echolocation clicks (such as those of beaked whales) for the BSURE replacement phones. Significantly, the replacement BSURE phones also provide a much lower frequency response (advertised 50Hz vice 100Hz) which is enabling detection of 20Hz to 40Hz sounds from large baleen whales (blue, fin, sei, etc.). This opens up additional capabilities for detection of marine mammals, while retaining similar area coverage of the previous hydrophones.

Marine mammal localization and exposure estimates

This exercise has multiple species (minke, beaked, pilot, sperm and humpback) on, or near, the range and vocal during the Feb 2011 exercise. This allows potential repeated localization of the marine mammals by passive acoustic processing methods vice single sighting updates by trained marine mammal observers. Currently only automated techniques are available for localizing minke whale species (Martin et al. 2011) using their "boing" calls (Rankin and Barlow 2005). The automatic localizations show a minke whale on north BSURE from around 02:00 on the 17th through about 10:00. The automatic localizations are believed to be from a single minke whale as the acoustic peak frequency in the 1350Hz to 1440Hz detection band (Mellinger et al. 2011) is nominally 1400Hz (+/- 3Hz) over the entire period and the intervals between these boings corresponds to nominal inter-boing-interval rate of around 6 minutes (Thompson and Friedl 1982). A minke whale visually sighted on the range on 27 April 2009 (Martin 2011) was determined to have a mean inter-boing-interval of 377 sec (sd 112s) with a peak frequency in the detection band of 1384Hz (sd 1.78Hz). The automatic localizations for the 17th were refined for fifteen boings between 05:58 and 07:37 by manually validating the calls, obtaining more accurate start times and utilizing the same two dimensional time difference of arrival hyperbolic localization routine used in the automatic localization. Table 2 provides the times of minke boings utilized in this analysis, which recorded data file the call is detected in, the inter-boing-interval and latitude and longitude of the call source location. Notice that there are three areas where the intervals are significantly larger than the rest marked with asterisks in table 2. This could be due to the animal not making calls between these times, calls being masked by MFA signals, or the animal significantly reducing the level of calls during these periods.

Figure 2 shows a course scale view of the area of the PMRF BSURE range during this analysis period the morning of 17 Feb 2011. The range hydrophones are labeled as three digits with leading alpha characters (i.e. I10, J09, K11, L10), the DDG ship position shown as plus signs with labels and arrows to indicate the times, in a similar manner the fifteen minke whale positions from table 2 are shown as open squares. Two additional symbols show the location of the DDG sighting of a group of between 3 and 5 unidentified whales (open circle at 07:39), and the single manually derived humpback whale position shown as an open diamond at 07:36. Localization accuracy is estimated to be approximately +/- 200m for the minke whale – hydrophone geometry shown using hydrophones J09, I10, K11 and L10 to localize the minke whale.

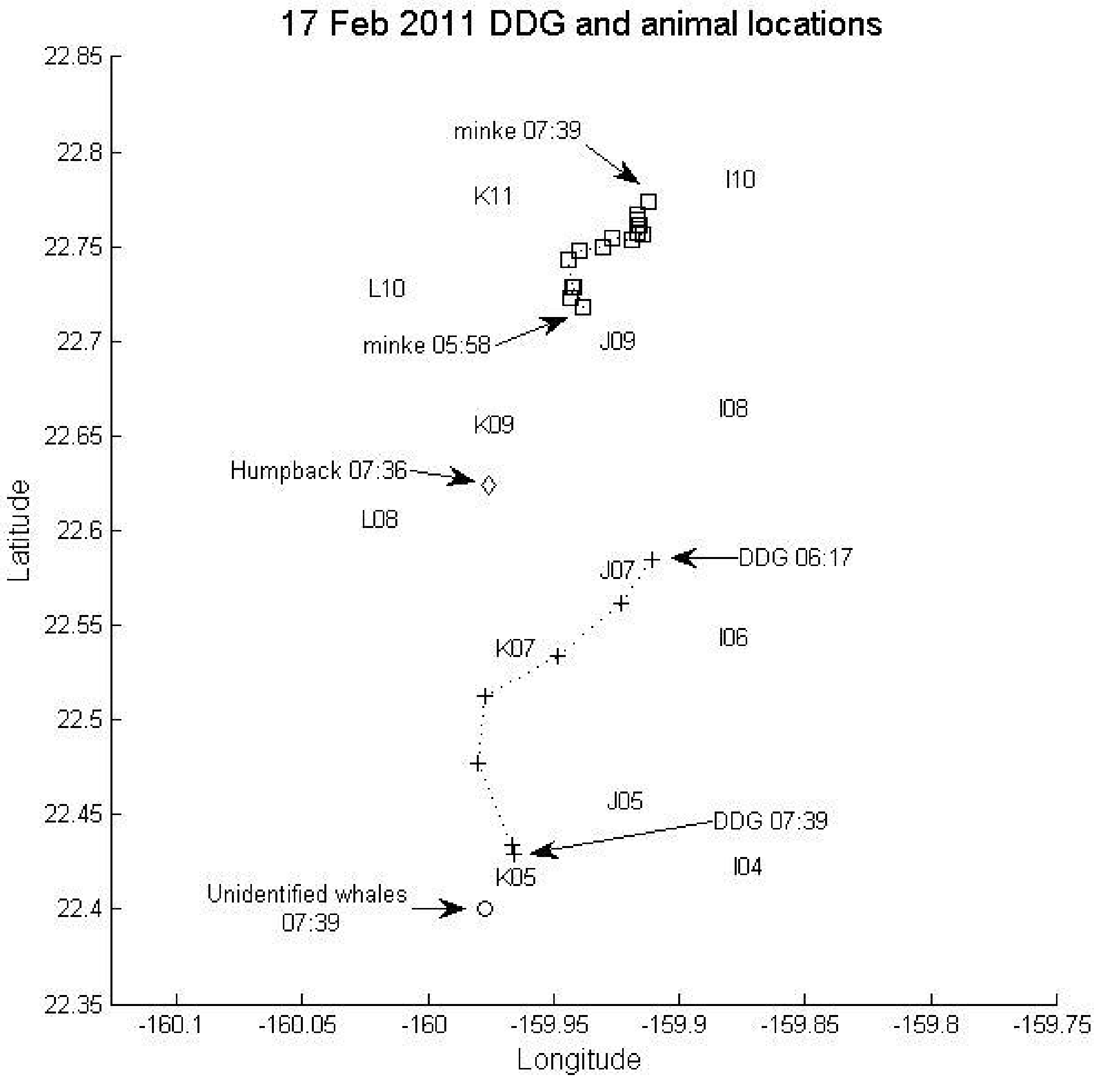

Figure 2 – Plan view of positions of DDG (plus symbols) and whales (minke square symbols, humpback single diamond, unidentified group of whales open circle) between 05:58 HST and 07:39 on 17 Feb 2011. Closest distance from DDG during MFA transmits for unidentified whales are 3.4km at 07:38, followed by 16.3km at 06:17 for minke whales followed by 21km at 07:36 for humpback whale. Note that for the humpback case the whale is nearly astern of the DDG.

Figure 3 shows an expanded view of the minke whale position updates with additional time labels. The animal in general is advancing northward; even before the first MFA of this exercise (of course there were MFA signals a few hours prior in the miniwar II event). The first 3k MFA occurred at 06:17:18 (times reference to closest bottom phone reception time) which is 95s after the animals fourth boing in table 2. Over twelve minutes elapses before detecting the animals' fifth boing. One might expect an additional boing call in between the forth and fifth calls however if one were present it was either very low level compared to other boings from this animal, or it was masked by the MFA signals which saturate the hydrophones for brief periods. The distance the minke traveled between the boings at 06:15:43 and 06:27:50 is estimated as 1.61km in the 717 seconds (2.25m/s or 8.1km/hr). This speed is 66% of that seen between the first and second boings at 05:58:58 and 06:04:38 where the minke is estimated to travel 1.16km in 340 seconds (3.4m/s or 12.2km/h). These speeds are slightly less than reported for the individual sighted by Rankin and Barlow 2005 (5.6km/h) and reasonable relative to reported normal swim speeds of 4.8 to 25km/h. The observed swim rates are also well below maximum burst speeds of up to 34km/h. The animal continued what one would consider normal boing call intervals during the entire 80 minutes of 3k MFA activity and did not exhibit high swim speeds. The animal is observed to be advancing towards the north while the exercise ships were generally advancing south. The animals advance direction is away from the MFA ship, however it was also trending north before the first 3k MFA transmission. Throughout the 05:58 to 07:39 analysis time the animal is within an area defined by four hydrophones (i10, j9, k11 and L10) which generally results in good localization accuracy. It is interesting to note that the higher frequency components of the individual boings are better received at some hydrophones vs. others presumably due to the directional nature of the higher frequency components (which go to over 11kHz) of the boing. If one speculates that the highest frequencies and highest amplitudes are emitted from the front of the animal this gives an indication of where the animals head is pointed at the time of the boing. This illustrates the potential of information possible about marine mammals using acoustic data.

Table 2 – Minke whale boing detection times on phone J9, inter call intervals and locations for exposure analysis of 17 Feb 2011 05:58 to 07:37.

Boing time hh:mm:ss (HST)	Data file sequence # 16Feb11_235737_	Inter Boing Interval (sec)	Lat (dd.ddd)	Lat / long (dd.ddd)
05:58:58	97	Na	22.7184	-159.9387
06:04:38	97	340	22.7283	-159.9423
06:10:29	98	351	22.7233	-159.9432
06:15:43	98	314	22.7283	-159.9430
06:27:50	100	727 *	22.7428	-159.9442
06:33:28	100	378	22.748	-159.9398
06:44:17	101	649*	22.7499	-159.9305
06:49:55	102	338	22.7543	-159.9266
07:00:49	103	654*	22.7532	-159.9191
07:06:43	103	354	22.7568	-159.9149
07:12:26	104	343	22.7574	-159.9168
07:18:25	105	359	22.7608	-159.9163
07:23:39	105	314	22.764	-159.9168
07:30:37	106	418	22.7673	-159.9168
07:37:02	106	385	22.7739	-159.9126

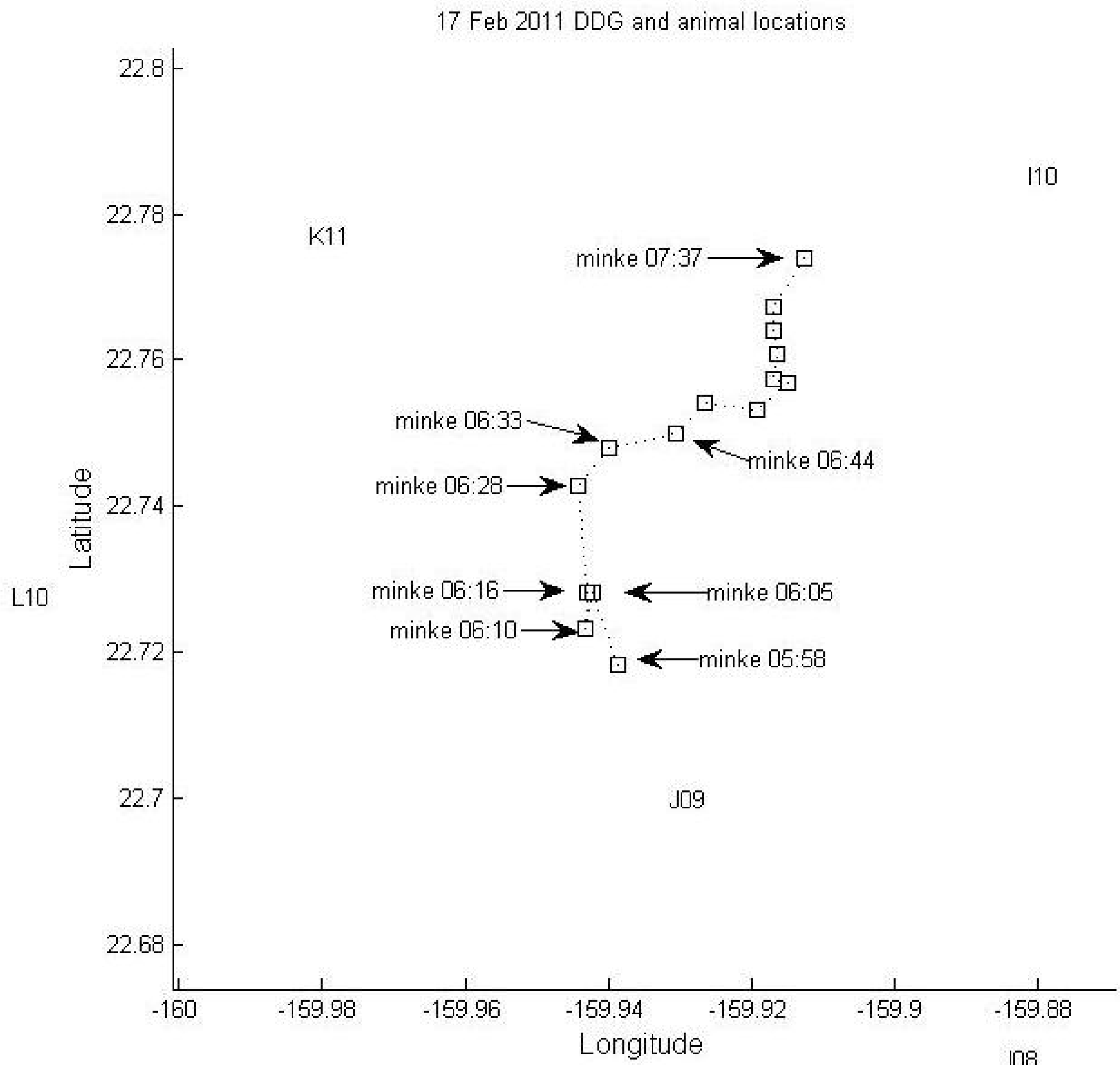

Figure 3 – Close up of minke whale position updates (square symbols) from 05:58 through 07:37 for fifteen boings in table 2. Three bottom hydrophone approximate locations indicated by the J09, K11 and I10 labels. Arrows show approximate times of minke boings so direction of travel is observable. Dotted line connects successive position updates for linking positions rather than implying the animal traveled the dotted path. Initial 3k MFA transmission occurred just after the 06:16 position update and the last transmission from this event occurred at 07:38.

The positional data in table 3 summarizes the ship-whale locations and orientations for the three 3k MFA transmissions analyzed for exposure levels. There were many 3k MFA transmissions from the DDG and additional higher frequency MFA transmissions from the other two surface ships in this event (miniwar III). For simplicity in this analysis the bottom depth is considered flat and fixed at 4550m, 3kHz is the frequency for the analysis, a sea state of 2 will be utilized. Higher sea states increase the mixed layer (surface) duct leakage coefficient, which in turn reduces the exposure level.

Table 3 – Positional data for localized marine mammals and surface ship transmitting nominal 3kHz MFA signals between 06:15 and 07:39 on 17 Feb 2011 during SCC miniwar III event. Times shown for the DDG location correspond to 3k MFA transmission times as received by the closest bottom hydrophone. Estimated DDG heading based upon successive updates of positions vice heading sensor data. Range and true bearing to animal from DDG, along with relative bearing to the whale from the DDG ship also shown.

Time (HST) hh:mm:ss	DDG posit at transmit time or whale posit	Latitude (dd.dddd)	Longitude (ddd.dddd)	est. DDG heading (deg true)	Range (m) & brg DDG to animal	Relative brg DDG to animal
06:15:43	minke acoustic posit	22.7283	-159.9430	na		
06:17:18	DDG posit at transmit time	22.5844	-159.9111	255	16,300 @ 349 true	94
07:36:45	Humpback acoustic posit	22.624	-159.9762	na		
07:35:51	DDG posit at transmit time	22.43443	-159.96617	180	21,000 @ 347 true	167
07:38:07	DDG posit at transmit time	22.4289	-159.9661	180	3,390 @ 201 true	21
07:39:09	Unidentified whale visual posit (group of 3- 5)	22.4002	-159.9775	180	3350 @ 20 rel	20

Plugging values into equation 2 and the ray trace program, one arrives at exposure levels for the three 'encounters' shown in table 3. Each of the two estimation methods, equations and ray trace model, provide output in most cases. Table 4 summarizes the estimated sound pressure levels the animal is exposed (Le) to from two propagation paths (surface duct / direct and bottom bounce).

Table 4 – Estimated exposure of marine mammals (sound pressure level) for marine mammals the morning of 17 Feb 2011 as determined by sonar equation and ray trace models for both a surface duct, or direct path, and one bottom bounce of sound from seafloor to animal.

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

Model validation efforts

Validating the estimated exposure level is attempted utilizing measured bottom hydrophone data. This process is hampered due to the saturation of the bottom hydrophone data at approximately 120dB re uPa based upon nominal hydrophone response of the BSURE replacement hydrophones considering system gains through the system and for the data recorder utilized. Figure 4 shows the ray trace from the DDG location to bottom phone (phone j9 at 15km horizontal distance) case showing the direct path and bottom-surface multipath propagation for a bottom depth of 4550m. This phone was selected for being in the same azimuthal direction as the minke whale at 06:15 on 17 Feb for the estimated exposure analysis. The direct path arrives at the bottom phone with a modeled level of 149.4dB re uPa (saturated) with the bottom-surface multipath arriving with a level of 146 dB re uPa at 3.04s after the direct path arrival. The ray trace model is not allowing for bottom or surface reflection losses. Actual measured data shows the show the direct path signal at the J9 bottom phone badly saturated, and the bottom-surface multipath right at the saturation level of 120dB re uPa arriving 3.5 seconds after the direct path. The actual data shows a slightly longer delay between the two arrivals and a 26dB weaker signal than the ray trace model predicts. This difference could potentially be explained by a combination of: 1) a 7dB bottom reflection loss; 2) a 4dB surface reflection loss; and 3) a 15dB loss due to the launch angle being significantly off the transmitters' elevation maximum response angle (MRA). The use of actual measured data to validate models (both equation and ray trace models) is strongly encouraged to ensure the models are predicting values one sees in the real world. This exercise shows the magnitude of errors possible when using models that do not properly represent actual conditions.

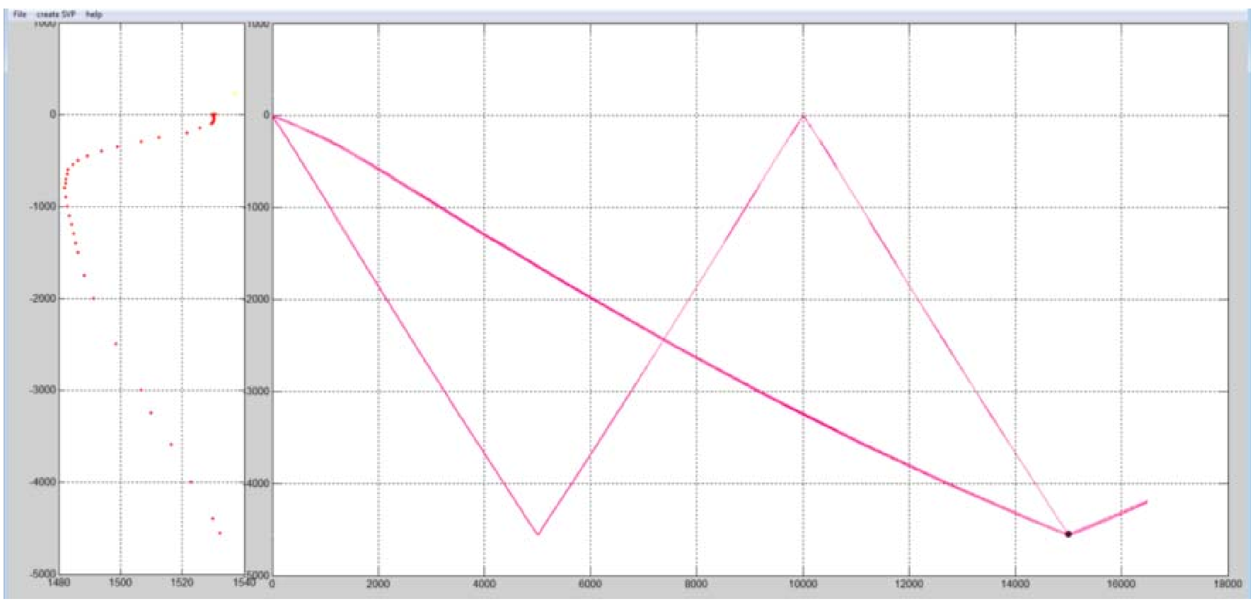

Figure 4 – Ray trace showing direct and bottom-surface multipath of sonar signal from DDG to phone J09 (15km horizontal distance) . Direct path receive level is 149dB for -11 degree vertical launch angle, close to same bearing angle of the minke whale position at 06:15 on 17 Feb. The bottom-surface path, -39 degree launch angle, arrives 3.02s after the direct path and at a level of 146dB.

Minke average boing rate

Figure 5 provides the average boing rate per hr over the 16 most offshore BSURE replacement phones for comparison to results of the Feb 2010 minke whale boing rate analysis. The peak boing rate of over 300 boings per hour occurred around 23:53 on 20 February. This seems to be due to multiple animals on the range and from the rapid boing rate increase previously reported when two animals are in close proximity to one another (Thompson and Friedl 1982). This phenomenon warrants further investigation utilizing the automated tools availble for the minke boing call. The depressed boing rate during the first three miniwar events observed may have contribution from MFA masking the detection of boings, however the boing rate increases during the last half of the minwar events. The lower rate observed for miniwars I through III should also be viewed in light of the pre-event rate and fact that the boing rate was in decline during torpex III. The high degree of variability is observed as it was in the before and after Feb 2010 SCC analysis.

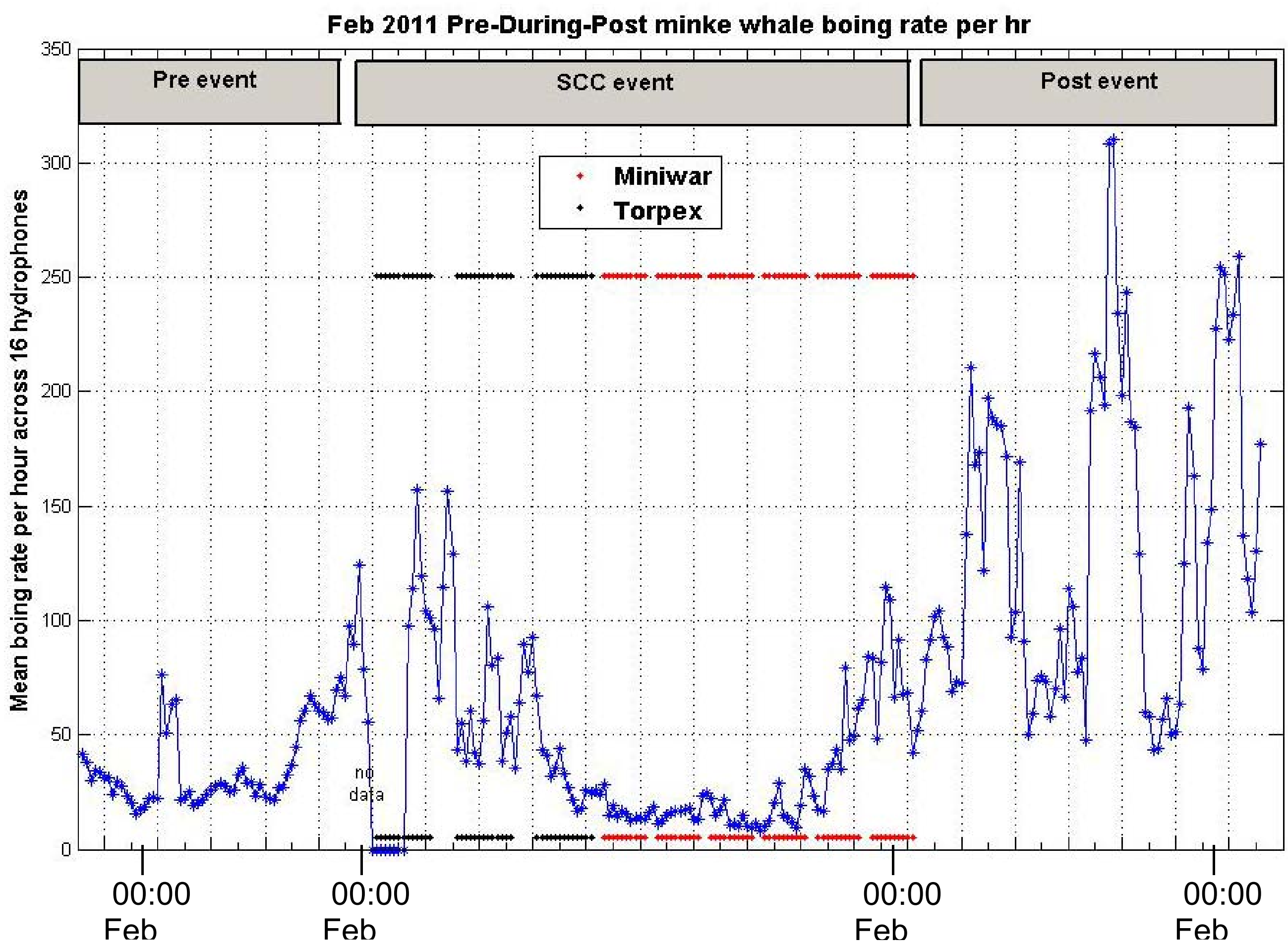

Figure 5 – Average minke boing rate per hour over 16 northern BSURE replacement phones.

The average boing rate, and its standard deviation, for the before, during and after exercise is shown in figure 6. The SCC itself is broken down into two components, the torpex phase (three submarine on submarine events) and the miniwar phase (six surface ships on submarine events).

The pre-SCC mean rate is seen to be 39.3 boings per hour (sd 22.4) over 16 phones, 65.6 boings per hour (sd 37.5) for the torpedo exercise portion of the exercise, 29.8 boings per hour (sd 26.1) for the miniwar portions of the exercise and 129 boings per hour (sd 70.5) after the exercise. While statistical significance tests does show differences in these boing rates, one must be cautioned in attributing these differences to being due soley to the exercise as the normal variations are not fully understood and the low boing rate could be due to fewer calling animals in the area and coincidental with the Navy activity.

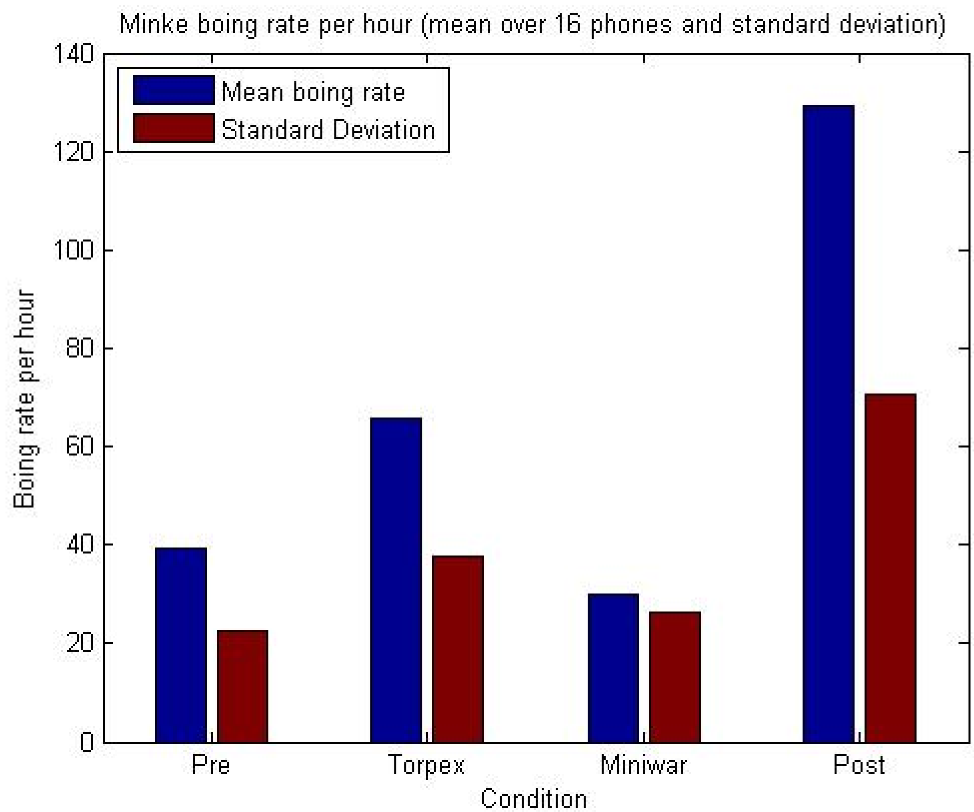

Figure 6 – Average minke boing rate, and its standard deviation, over 16 hydrophones. The SCC exercise is broken down into two components, torpex and miniwar.

Beaked whale detection, validation and dive vocal periods

The beaked whale automatic detection process performed on data from the Feb 2010 SCC (Martin informal report Aug 2010) for 13 hyrdrophones was duplicated on Feb 2011 SCC data for 16 hydrophones. With the higher frequency response of the new BSURE replacement hydrophones, the beaked whale analysis for this exercise represents more than a fourfold increase in available data (twice the temporal data and 30 vice 13 hydrophones). Therefore, effort was initially directed at streamlining the beaked whale validation process to be fully within matlab and allow for visual review of time series, spectrogram and wigner-ville transforms of the signals, along with aural replay at lower sample rates to time shift the data down into the human audio range.

The beaked whale validation process operates on one hydrophone at a time. An operator first reviews available overview type information for each hydrophone, such as long term spectral averages and automated screener and beaked whale click detections, to select a hydrophone and time frame for validation analysis. The validation process then displays a histogram of the inter-detection-intervals for the automatic detections of beaked whale clicks along with the screener detection histograms (all acoustic detections above threshold) as shown in figure 7 for hydrophone 406 in one ten-minute data file. These intervals are one classification clue for beaked whale clicks and the relationship of the intervals provides insight relative to beaked whale presence in the 10 minute data file. In cases where the screener detections are prolific and small values (eg. under 0.1s) one would suspect a high probability of false beaked whale detections. Conversely, when the screener inter-detection-interval is similar to that shown in Figure 7 lower trace, one has higher confidence that there is actually a beaked whale present vice some other odontocete species such as short-finned pilot whales or dolphins. The peak around 0.3 seconds shown in figure 7 keeps this as a viable candidate for actual beaked whale click validation, notice however, that in this case for hydrophone 406 only a small percentage of screener detections are declared beaked whale clicks. This is a result of the very conservative manual validation classification of beaked whale clicks in order to ensure we are correctly identifying areas of beaked whale echolocation foraging click activity.

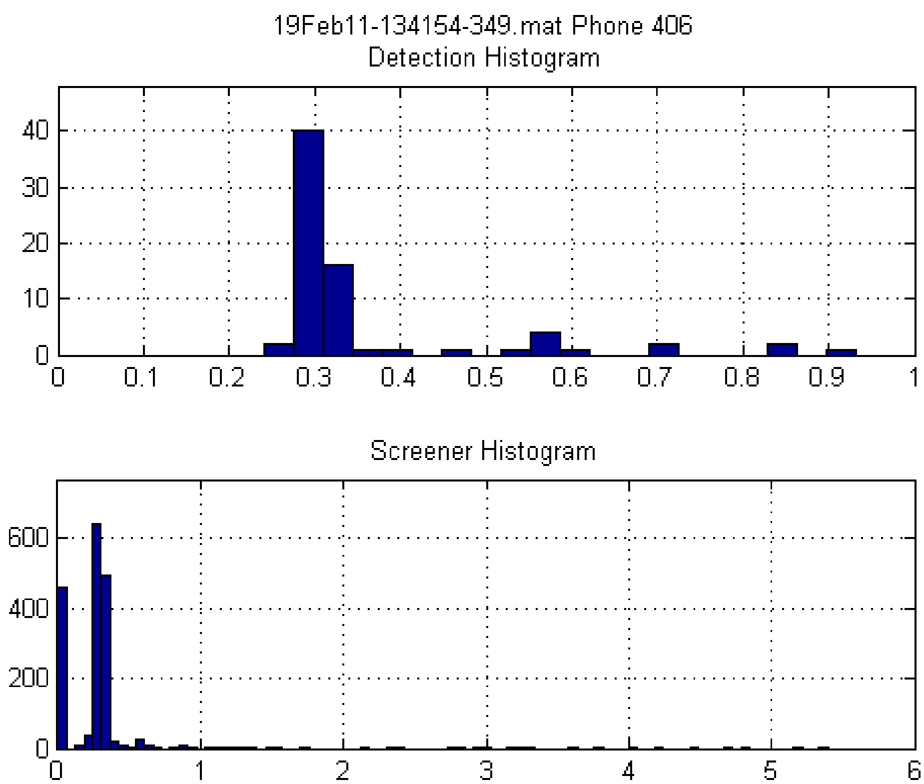

Figure 7 – Inter-detection-interval for ten minutes (one file) of one hydrophone's automatic beaked whale echolocation click detector. The lower plot shows inter-detection-intervals for all acoustic detections over threshold, while the upper plot shows only those detected clicks which meet the criteria to be declared beaked whale echolocation clicks. The groupings around 0.3 seconds are a feature of valid beaked whale clicks.

The next step in the validation process is to go through each automatic detection on the selected hydrophone and make a decision if the signal is indeed a beaked whale foraging echolocation click. This is accomplished by viewing the time series (both click level and for 1 second of data), filtered spectrogram utilized in the FM click decision, a full bandwidth spectrogram and wigner-ville transform of the suspected click. Figure 8 provides a screen shot of the tool being used to validate a beaked whale click from the post SCC period on hydrophone 406. A button is available for listening to the click at a slowed rate for aural analysis.

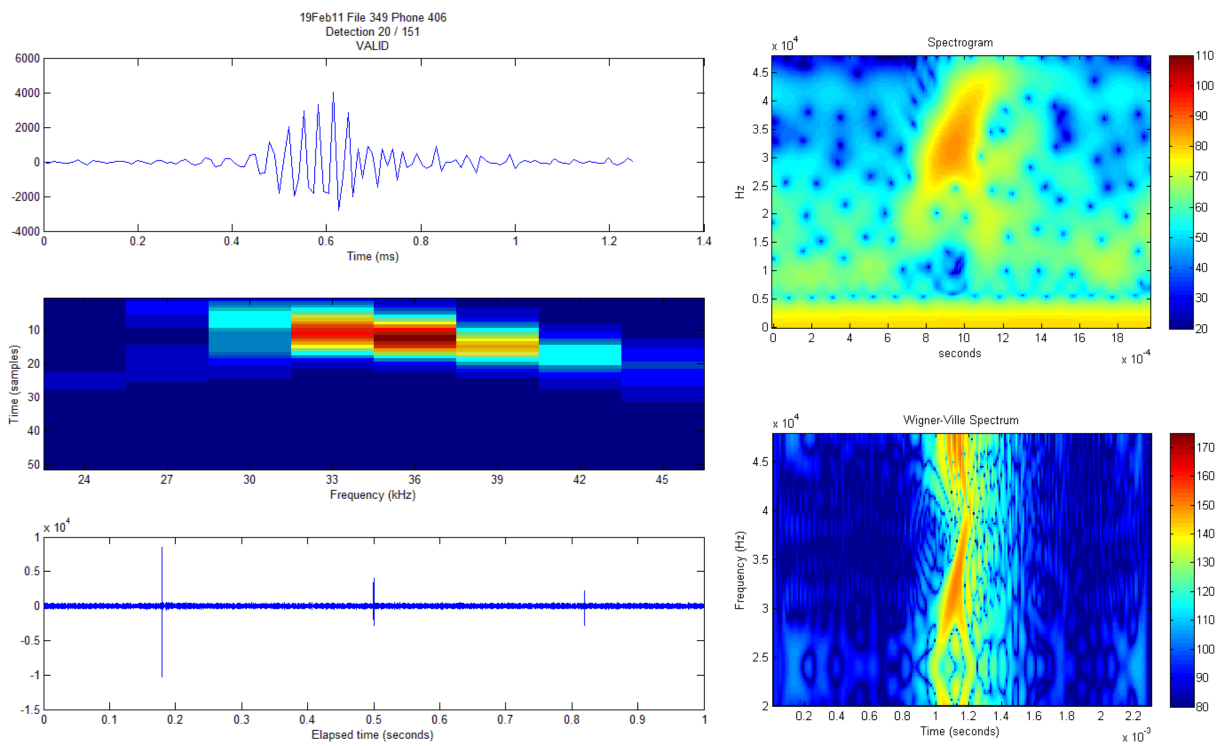

Figure 8 – Screen shot of beaked whale validation process in matlab. Left upper shows time series for 1.2msec of data, left middle shows the frequency (horizontal) vs samples showing the FM sweep, lower left shows one second of data showing click under investigation at 0.5s and additional clicks before and after. Right panels show: upper – short time FFT of unfiltered data and lower – wigner ville transform of click.

After validation of suspect areas of beaked whale foraging click activity for multiple hydrophones and time frames, one can put together a summary of the validation results. Table 5 provides results of the validation analysis for beaked whale foraging clicks for the pre-SCC period, SCC torpex period, SCC miniwar period, and post SCC period. One sees similar numbers of dive vocal periods per hour for the pre-SCC and SCC-minwar periods and slightly lower numbers for the SCC-torpex and post-SCC periods. Difficult to make any sense out of that relative to MFA sonar activity (SCC-miniwar) as the dive vocal periods per hour are similar to the pre-SCC period and higher than both the post-SCC and SCC-torpex periods. The number of hydrophones in this analysis does NOT guarantee detecting beaked whale dives due to limited spatial sampling, thus one simply uses this analysis to indicate that there was beaked whale activity over the range area throughout the time period. This does not fit with what has been seen at AUTEC in terms of beaked whales leaving the area during MFA activity and returning afterwards. However, the PMRF area is large compared to AUTEC (Moretti et al. 2010) and it is possible beaked whales could continue activity distant from MFA activity, or alternatively that the beaked whales have become acclimated to the MFA activity.

Table 5 – Summary of validated beaked whale foraging clicks grouped into dive vocal periods for the pre-SCC, SCC-torpex, SCC-miniwar and post-SCC.

	Pre-SCC 11-13 Feb, 2011	SCC-torpex 14-16Feb, 2011	SCC-miniwar 16-18 Feb, 2011	Post-SCC 19-22 Feb, 2011
Time (hours)	61.67	52	61.67	79.17
Dive Vocal Periods	44	31	49	46
Dive Vocal Periods/hr	0.713	0.596	0.795	0.581
BW Clicks in dives	1831	2062	3269	2245
BW Clicks per hour	29.69	39.65	53.01	28.36
BW Clicks per dive	41.61	66.52	66.71	48.80

When some marine mammal species move through the range (possible melon headed whale, pilot whales, other blackfish) in large extended groups, one hydrophones 10 minute file can contain thousands of false positive beaked whale click detections (suspect due primarily to pilot whale clicks). By evaluating the overall screener acoustic detections (shown in Feb 2010 report) one essentially rejects full validation on these files as even with a streamlined tool as this, it would take excessive time. The dive vocal periods per hour shown in table 5 is felt to be a meaningful metric whereas the number of clicks detected is highly variable depending upon the distance from the diving beaked whale group to the hydrophone.

It is interesting to note that there were validated beaked whale clicks from hydrophones far offshore in water depth near 5km. This was not expected and previously the offshore phones did not respond to beaked whale click frequencies. For the pre-SCC period over 10% of the validated beaked whale dive vocal periods and validated beaked whale clicks came from phones J9, L8, I8 and I10.

Other species

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

Some impact type sounds (center frequency < 1kHz) are also observed during exercises. It is unclear if these are man made in origin or could be from whale breaching, or tail/fluke slaps on the surface.

Humpbacks: Humpbacks were on the range during the exercise in Feb 2011 and were sighted by both surface craft (DDG) and an aerial survey conducted by Joe Mobley/HDR within relatively short distances of the DDG (a few km's). Manual analysis has been conducted in attempt to develop a method for automatic localization of humpback whales, which has met with limited initial success.

One effort at localizing humpbacks sounds occurred in time around the 17 Feb 07:39 HST period, which ties in with the analysis reported for minke whales and the unidentified group of whales sighted from the DDG. The low frquency sounds were also observed in this area on phone L08 at 07:42. Effort at localizing one humpback at 07:36:45 (file sequence 106) on phones I08, J07 and K07 allowed a localization as reported in table 3 and shown on figure 2. The signal being utilized was 202-287Hz upsweep of 0.34 s duration followed 3.563 s later by a 135Hz-234Hz upsweep signal. Note that for minke whale localizations we require four good hydrophone arrival times, it is appearing more difficult to associate the same humpback calls on four different hydrophones in efforts to date.

An earlier effort focused on file 359 for the recording started 16 Feb (actual time 01:37 on 19 Feb) for phones i10, j9, i8, k11 humpback whales. A sequence of humpback calls were localized to 22.7399 -159.8812, 22.7407 -159.8794 and 22.7403 -159.8788 which are all close to one another giving confidence in the process as aural analysis confirms the calls are from the same animal. There are also minke boings (potentially at the rapid rate) occurring, humpback upsweeps, and the 'barking' type thump trains here in the first 1 min of data on J9. There exists a need to better associate humpback calls across hydrophones and investigate the "barking" or thump train type signals to see if the sounds are produced by humpbacks or some other species. Due to the repeated calls similarity for humpbacks this process is felt to be to immature at this time and needs more work for reliable localization. This is highly desired as the exposure levels should be significantly higher than the one case for minke whale presented herin, and the spatial location updates may reveal swim speed and direction of travel relative to the DDG. In addition, careful analysis of the vocalizations should be done to determine if they are song units or non-song units, and if non-song units when they have been observed by researchers previously (behavioral states, etc.). Analysis of an encounter on 18 Feb 2011 at 09:47 of the actively transmitting DDG with a group of humpback whales at close range is currently under investigation (sighting # 14).

Short-finned pilot whales: Personnel from Cascadia Research Collective (Baird et al. 2011) tagged short finned pilot whales before the exercise of which at least one came back onto the range during the AFTER SCC time period. Specifically the tag #51 animal had good satellite location (location class 3 for location accuracy of under 250m) at 19:05 Z on 21 Feb 2011 and was in close proximity to hydrophones 501 and K02. Automatic beaked whale click detections from these hydrophones at this time show echolocation clicks similar to beaked whales in terms of having some frequency modulation sweep present, but with less duration and lower center frequencies. These echolocation clicks are believed to be from the pilot whales.

Low frequency suspected fin/sei calls: The new BSURE replacement hydrophones are revealing 20Hz pulses and 40Hz to 20Hz downsweeps that are similar to calls reported for fin and sei whales. Figure 9 provides an example of the downsweep signals,for hydrophone J7 as received in file 380 of the recording started on 11Feb11 (23:32 HST 13 Feb 2011) on 22 seconds of data is shown from DC to 180Hz. This data is from the PRE SCC period from phone I6 and has acoustic evidence of humpbacks, some odontocete clicks, and these ~40Hz to 20Hz downsweeps which occur in groups of three. Similar signals from phones J7 and K7 were utilized to localize this call sequence to 22.3943 deg lat and -159.8439 deg long. The group of three pulses could be multipath versions of a single pulse. The low frequency analysis is tentative in the early stages of effort and it is currently unclear if the animal is near or very distant, which in the later case would invalidate the localization position as the code to localize assumes direct path arrival.

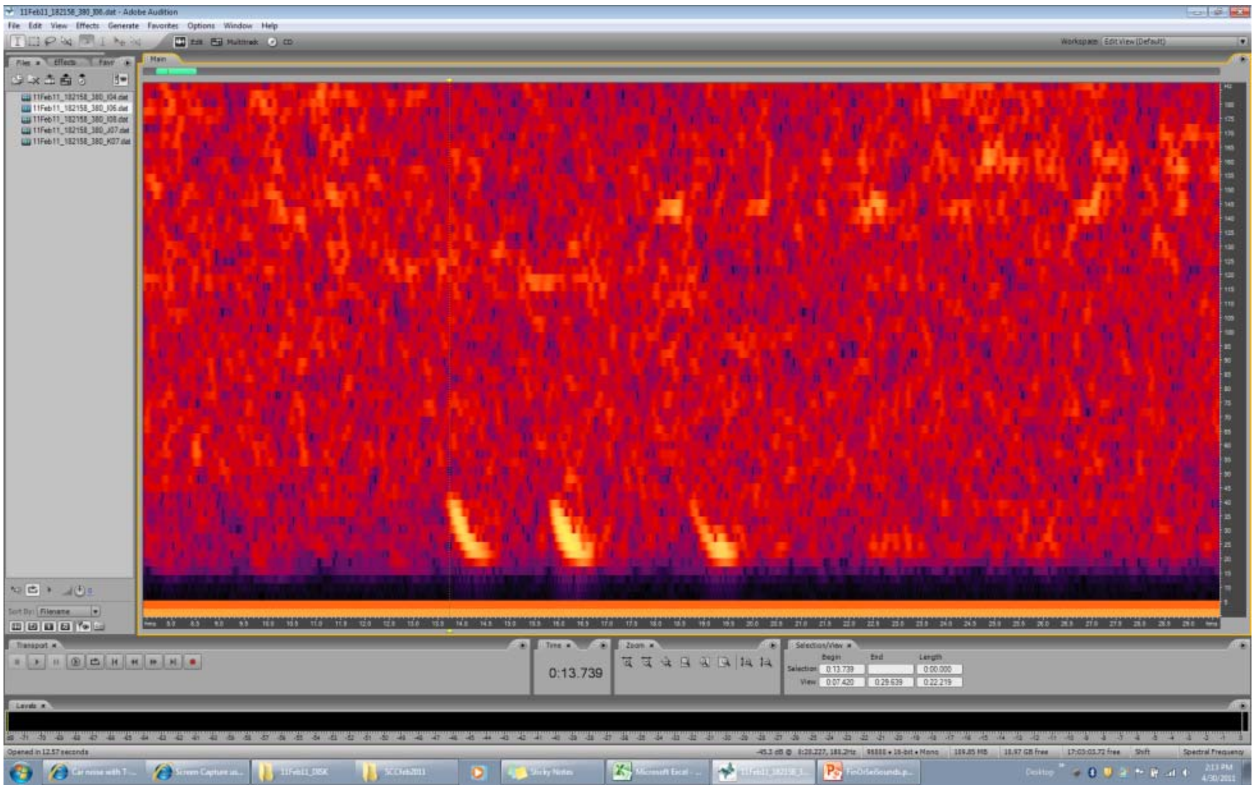

Figure 9 – Example of low frequency downsweeps in the range of 40Hz to 20Hz. This example is of 22 seconds of data from DC to 180Hz for hydrophone J7 on at 23:32 HST on 13 Feb 2011).

Very strong low frequency signals are present in data file 108 for the recording started on 16 Feb (actual time of this data is 17 Feb @ 07:51:12 HST). These have very strong ~35Hz to ~20Hz downsweep signals obvious on phones L8, K9 and L10, approx 0.8s duration every ~ 25 sec, which matches reported descriptions of fin whale pulses (Thompson and Friedl 1982, McDonald and Fox 1999) These signals continue through file 110 and are noted due to the very strong signal strenghts observed which may imply the animal is closer to the phones and potentially on the range. A juvenile fin whale was encountered in the area of 22.2 – 22.3, -159.68 to -159.77 at 1130 to 1230 HST on 16 Feb 2010 by the 57' sailboat Vanessa being utilized by the company Oasis for independent testing over this period during the SCC, the whale followed the sailboat over this period. This sighting was 19 hrs before these strong signals were picked up in an area ~30km to the N-NW of the visual sighting, too distant in time for any speculation as to wheather the sounds were from the sighted individual. 13:58 HST 16 Feb phone i10 has strong LF data, so not the same animal as sighted much farther south.

Discussion

Passive acoustic methods are seen to be a powerful tool when marine mammals are present and vocal on range for analysis of exposure levels of marine mammals during US Navy training exercises. Visual sightings can also be analyzed for exposure levels and use of passive acoustic data allows precise expsoure times and distances determination. The automated processing currently available for minke whale boing calls enables detailed analysis with minimal manually intensive analysis. For the case of minke whales, this analysis shows it is possible to evaluate behavioral response, in terms of swim rate and advance direction, relative to mid frequency active sonar transmissions. For the minke whale analyzed here, there does not appear to be a significant reaction by the minke whale to the MFA transmissions which occurred over 16km away with estimated exposure levels in the range of 139 to 145dB sound pressure level re micro Pascal. Unfortunately, we can not currently perform similar automatic processing for humpback and other large low frequency baleen whale sounds detected by the range hydrophones. Thus, extensive manual analysis is required to determine whale locations, and even this poses issues for humpback whales with repeatable calls and when multiple groups are present. The rapid rate of progress in the area of passive acoustic DCL should reduce the labor required for automated DCL for additional species as time progresses. Acoustic density estimation is also considered a valuable tool for understanding potential consequences of Navy activities on instrumented ranges, such as PMRF, as normal variations (both short term and long term) are better understood.

For this report one must rely on models to estimate the sound pressure level animals are exposed to. For close range cases the various models agree quite well with expected data. It would be very helpful to have shallow hydrophone(s) deployed (e.g. sonobuoys) during the exercise such that model validation efforts can be conducted for shallow depths where typical baleen whales are expected to be encountered. Similary collecting in-situ SVP's would also improve modelling efforts and PMRF has said they can collect SVP for future SSC's. At long ranges the various models do not agree with one another well (have seen 15dB differences in two high fidelity US Navy models for ducted propagation at over 15km). The sonar equation predicts on the order of 15dB more ducted transmission loss due to duct leakage than other models and this is using a sea state of 2. The actual sea state is reported to have been in the 4 to 5 range which would exhaberate this difference by another 10dB. Future modellling will use the PCIMAT standard US Navy model.

The products of this analysis show that it is possible to obtain results similar to those being sought by behavioral response studies (animal locations over time) with much less effort by monitoring ongoing US Navy exercises. The advantage of the US Navy exercise is that actual mid frequency sonar systems are utilized, vice surrogate sonars with less source levels. The disadvantage of the US Navy exercise is lack of controls and need to estimate exposure levels as there is not an acoustic tag on animals. Combining results from these exercises with research behavioral response studies could result in improved understanding.

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SOUTHERN CALIFORNIA RANGE COMPLEX

Monitoring in the Southern California Range Complex

This section reports results from the Navy's Year Three field monitoring efforts in the Southern California Range Complex from 02 August 2010 to 01 August 2011.

The Navy fully implemented the monitoring plan outlined in the Navy's 2009 Year Two Monitoring Report to NMFS (DoN 2010[6]) and specified in the Navy's subsequent 2010 Letter of Authorization renewal application for study Year Three from 02 August 2010 to 01 August 2011 within the Southern California Range Complex. Monitoring efforts were funded by the Navy's U.S Pacific Fleet as required for compliance monitoring under the Navy's annual Letter of Authorization. Additional marine mammal monitoring within Southern California, part of a larger research program, was funded by the Energy and Environmental Readiness Division of the Chief of Naval Operations. Some results from this research monitoring with complementary objectives as Navy's compliance monitoring are presented in this report, where applicable. Monitoring fieldwork in the Southern California Range Complex was performed by civilian scientific organizations and companies with significant experience in ocean monitoring for marine species. These include Scripps Institute of Oceanography, Smultea Environmental Services, Cascadia Research Collective, and National Marine Fisheries Service's Southwest Fisheries Science Center. Experienced civilian field biologists from various Navy commands participated in the marine mammal observer event.

Monitoring accomplished in Year Three within the offshore waters of Southern California included aerial and vessel visual marine mammal and sea turtle surveys, the embarkation of marine mammal observers on a Navy surface ship, and passive acoustic marine mammal monitoring from multiple bottom-mounted acoustic recording packages.

Report Organization

This report is organized to summarize the Navy's monitoring commitments and Year Three accomplishments within the Southern California Range Complex. Specific subsections include:

- Visual Survey Results
- Marine Mammal Observers (MMO)
- Passive Acoustic Monitoring (PAM)
- Southern California Range Complex Exercise Summary
- Other Navy Funded Research Results- Other visual surveys, marine mammal tagging, Marine Mammal Mitigation on Navy Ranges (M3R), and photographic identification (PhotoID).

6 DoN. 2010. Marine Mammal Monitoring For the U.S. Navy's Hawaii Range Complex and Southern California Range Complex-2010 Annual Report. Department of the Navy, U.S. Pacific Fleet. 582 pp.

Year Three Monitoring Locations

While all nearshore and offshore ocean areas within Southern California Range Complex are acceptable for monitoring depending on the technique being used, certain portions of the range complex were designated as "focal areas" based on scientific merit for study in that location, logistics of being able to safely reach the site especially for shore-base airplane surveys, proximity to key Navy training areas, and previous field experience from past Navy monitoring in 2009 and 2010.

Figure S-1 shows the general Southern California focal areas surveyed the most during Year Three (from 02 August 2010 to 01 August 2011). The Navy added a fourth focal area for Year Three monitoring within the Southern California Range Complex. This forth area located closer to San Diego was primarily focused on visual survey.

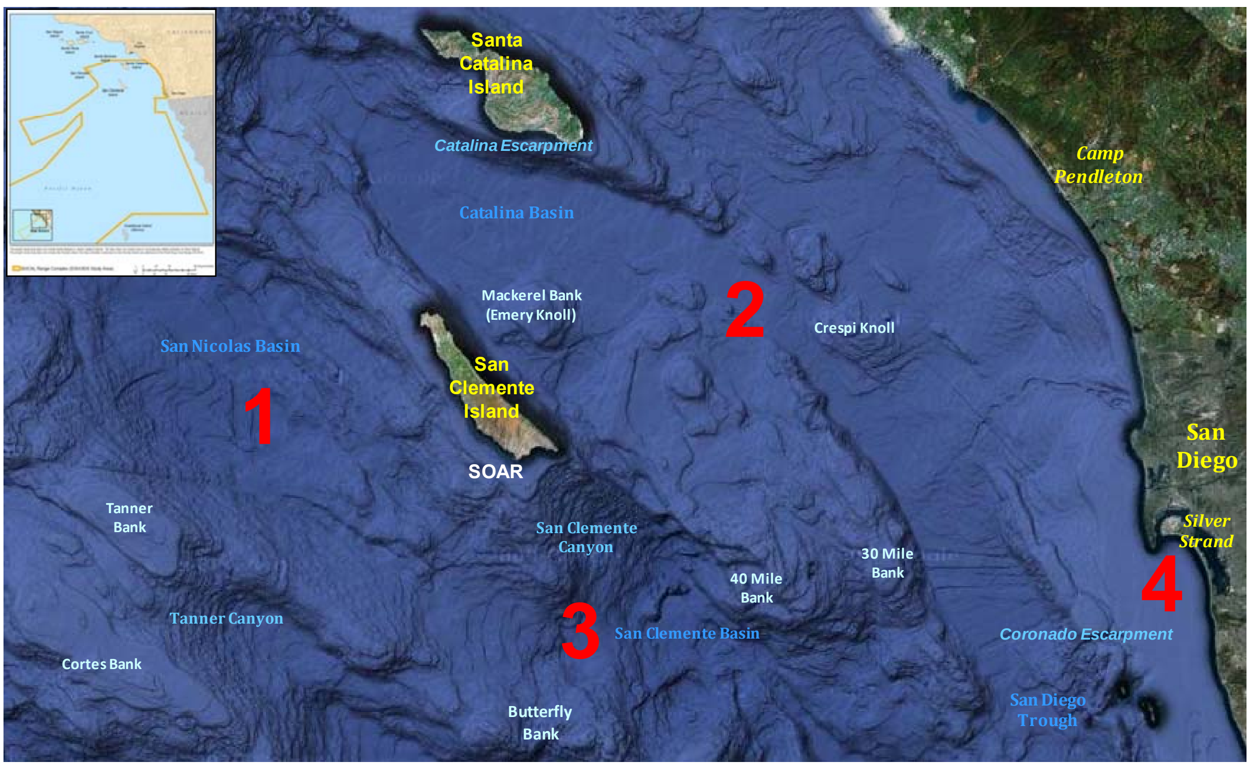


Figure S-1. Study focal areas for Year Three monitoring within the Southern California Range Complex.

Oceanographic Conditions

The Navy's previous 2009 and 2010 Monitoring Reports discussed the importance of regional oceanographic conditions on potential marine mammal occurrence within Southern California (DoN 2009[7], DoN 2010). These include the El Niño (warm water regime) and La Niña (cold water regime) oscillations, the longer term Pacific Decadal Oscillation, and global climate change. While the Navy's 2009 Monitoring Report highlighted these changes from 1950 to 2009 (DoN 2009), **Figure S-2** instead shows an updated summary of Pacific sea surface temperatures as an indicator of oceanographic condition covering the period from 2008 through 2011, with the Navy's Year Three range complex monitoring period indicated in **Figure S-2** by the dashed lines around the appropriate months.

Eastern Pacific Warm and Cold Water Periods 2008-2011

DESCRIPTION: Warm (red) and cold (blue) episodes based on a threshold of +/- 0.5°C for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v3b SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W)], based on the 1971-2000 base period. For historical purposes cold and warm episodes (blue and red colored numbers) are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.
From: National Weather Service Climate Prediction Center
http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2008	-1.4	-1.4	-1.1	-0.8	-0.6	-0.4	-0.1	0.0	0.0	0.0	-0.3	-0.6
2009	-0.8	-0.7	-0.5	-0.1	0.2	0.6	0.7	0.8	0.9	1.2	1.5	1.8
2010	1.7	1.5	1.2	0.8	0.3	-0.2	-0.6	-1.0	-1.3	-1.4	-1.4	-1.4
2011	-1.3	-1.2	-0.9	-0.6	-0.2	0						

warm period scale		*cold period scale*	
(yellow)	+0.5 to 0.7°C (+0.9 to 1.3°F)	(light blue)	-0.5 to -0.7°C (-0.9 to -1.3°F)
(orange)	+0.8 to 1.0°C (+1.4 to 1.8°F)	(blue)	-0.8 to 1.0°C (-1.4 to 1.8°F)
(dark red)	? +1.1°C (? +2.0°F)	(dark blue)	? -1.1°C (? -2.0°F)

Figure S-2. Warm and cold ocean temperature episodes base on Oceanic Niño index as a predictor of El Niño and La Niña oceanographic conditions within SOCAL from 2009 to 2011.

During Year Three monitoring, there were lowered sea surface temperatures from August 2010 through May 2011 indicative of a cool water La Niña condition. Current indications through summer of 2011 indicate a return to an El Niño\La Niña neutral condition.

7 DoN. 2009. Marine Mammal Monitoring for the U.S. Navy's Hawaii Range Complex and Southern California Range Complex-2009 Annual Report. Department of the Navy, U.S. Pacific Fleet. 582 pp

SOUTHERN CALIFORNIA RANGE COMPLEX YEAR THREE MONITORING ACCOMPLISHMENTS

To assess the Year Three SOCAL Range Complex monitoring, each monitoring objective in this year's effort is presented along with discussions of accomplishments, metrics of completion, scientific contribution, and overall value to the monitoring program. Following a brief summary, individual subsections will discuss each monitoring subject. Longer field reports from various researchers are either included within these subsections, or placed in an accompanying appendix if lengthy.

Year Three monitoring objectives include reporting annual results from:

- Visual Surveys
- Marine Mammal Observers
- Passive Acoustic Monitoring
- Southern California Range Complex Navy Exercise Summary
- Other Navy Funded Research Results- visual surveys, marine mammal tagging, passive acoustic monitoring, photographic identification (PhotoID), and population assessments

Year Three Overview

Tables S-1 and S-2 compares the Navy's Year Three monitoring accomplishments in terms of regulatory commitments to the National Marine Fisheries Service.

Table S-1. Overview of Navy compliance with monitoring requirements in the Southern California Range Complex.

Type of Monitoring	2011 Planned Monitoring as Committed To By The Navy	2011 Completed Year Three Monitoring Accomplishment
Compliance Funded Monitoring Visual survey	100-150 hours effort	1,001 hours of effort completed
Marine Mammal Observers	50-100 hours of effort	83 hours of effort completed
Passive Acoustic Monitoring	Continue data analysis from passive acoustic devices	20,704 hours recorded
Navy Exercise Summary	Present marine mammal sighting results from Navy major training exercises	428 sightings of approximately 5,848 marine mammals
Other Navy Funded Research Summaries	Present results for other Navy funded research projects as available (tagging, photoID, visual, passive)	14 satellite tags deployed during Year Three; provided in this report

Table S-2. Summary of Navy funded monitoring accomplishments within the Southern California Range Complex from 02 August 2010 to 01 August 2011.

Monitoring Study Type	U.S. Navy Fleet funded Compliance monitoring	Associated Navy training event	U.S. Navy funded Research monitoring	Associated Navy training event	Total YEAR Three (2010-2011) accomplished
Visual Surveys (VS)	28 hrs (A) 23-29 Sept 10	During/After MTE	57.5 hrs (R) 4-11 Jan 11	No MTE	**1,001 hours visual survey**
	17 hrs (A) 14-19 Feb 11	Before/During/After MTE	48.5 hrs (R) 4-11 Jan 11	No MTE	
	9.5 hrs (A) 29 Mar - 3 Apr 11	No MTE	59.3 hrs (R) 30 April – 7 May 11	Before/During MTE	
	46 hrs (A) 12- 19 Apr 11	No MTE	56.1 hrs (R) 1-7 May 11	Before/During MTE	
	27 hrs (A) 9-14 May 11	During MTE	46.1 hrs (R) 18 – 23 June 11 40.1 hrs (R) 21-25 July 11 111 hrs (R) 30 July 10 - 26 April 11 455 hrs (S) 30 July 10 - 26 April 11	No MTE No MTE Multiple Multiple	
Marine Mammal Observers (MMO)	83 hrs 4-7 April 11	During ULT	Not applicable	Not applicable	**83 hours of MMO**
Marine Mammal Tagging (MMT)	Not applicable	Not applicable	14 LIMPET satellite tags 4-11 Jan 11 30 April – 7 May 11 18-23 June 11 5 fin, 1 sei/fin, 1 Baird's beaked whale, 2 Risso's, 1 killer whale, 1 sperm whale, 3 Cuvier's beaked whale	No MTE Before/During MTE No MTE	**14 tags**
Passive Acoustics Monitoring (PAM)	2 Pacific Fleet Funded PAM devices (SIO's HARP) April 2010 to April 2011 15,878 hrs recorded	Not applicable	M3R on Navy instrumented range west of San Clemente Island continued field validation 2010, 2011	Before\ During\ After MTEs and ULTs	**2 PAM devices deployed for total of 15,878 hours of HARP recording; 4,056 hrs from M3R, plus 770 hrs from other passive**

Notes:

A= airplane platform, H= helicopter platform, S= ship platform, R= Rigid Hulled Inflatable Boat (RHIB)

MTE= major training event; ULT= unit level training;

SIO= Scripps Institute of Oceanography, HARP= high frequency acoustic recording package;

M3R= Marine Mammal Monitoring on Navy Ranges;

LIMPET= Low Impact Minimally Percutaneous External-electronics Transmitter satellite tag

As indicated in **Table S-1**, all Year Three monitoring objectives were met, and in some cases significantly exceeded.

Year Three Objective and Scientific Summary

The Navy met and vastly exceeded all of its Year Three monitoring objectives within the Southern California Range Complex (**Table S-2**). The total field effort of Year Three monitoring within the Southern California Range Complex is presented in **Table S-3**.

To date, the Navy's monitoring programs in Southern California have generated an extraordinary amount of data on marine mammal biology within the region, a significant amount of which is new to science. Some preliminary results will be presented in later subsections within this report, although data analysis continues with the goal of producing a more complete synthesis by the end of the NMFS authorization under which this monitoring occurs.

Highlights for Year Three monitoring include:

- 1,001 hours of survey effort
- 21,196 nm of ocean surveyed
- 1,225 sightings representing over 100,594 marine mammals
- Over 20,704 hours of passive acoustic recordings made
- 21,524 digital photographs of marine mammals taken
- 18.8 hours of digital video of marine mammals taken
- 44 tissue biopsies taken
- 14 medium term satellite tracking tags put on marine mammals

Table S-3. Cumulative total effort and accomplishments from Year Three Navy funded monitoring within Southern California from 02 Aug 2010 to 01 Aug 2011

N= CNO N45, P= U.S. Pacific Fleet, NPG= Naval Postgraduate School; Si= Scripps Institute of Oceanography, C= Cascadia Research Collective, Sm= Smultea Environmental Services

Navy funding	Performing Organization	Survey Dates or Window	Participating Vessels	# Days (days)	Total Survey Time (hrs)	Total Survey Distance (nm)	# Groups	# Individuals	# Species visually sighted	Digital Photo/ IDs taken (#)	Digital video taken (hrs)	Biopsies (#)	Satellite Tags (# tags)	# Passive recordings (#)	Total passive recording (hrs)	# Acoustic detection (#)	# Species acoustically detected (#)	# Passive sonobuoys (# buoys)
P	Sm	23-28 September 2010	airplane- Partenavia P-68-C	6	27.7	2,116	252	37,874	9	741	2.4	na	na	na	na	na	na	na
P	Sm	14-19 February 2011	airplane- Partenavia P-68-C	4	17.2	1,724	83	11,131	8	473	1.3	na	na	na	na	na	na	na
P	Sm	27 March - 3 April 2011	airplane- Partenavia P-68-C	3	9.5	1,007	71	2,165	8	323	1.6	na	na	na	na	na	na	na
P	Sm	12-20 April 2011	airplane- Partenavia P-68-C	9	46	5,926	146	14,530	11	424	4	na	na	na	na	na	na	na
P	Sm	9-14 May 2011	airplane- Partenavia P-68-C	6	27	2,647	81	3,309	11	976	5	na	na	na	na	na	na	na
N/NPS	C	4-11 Jan 2011	Zodiac RHIB	6	48.5	526	30	688	9	na	0.5	1	4	na	na	na	na	na
N/NPS	C	30 April - 7 May 2011	Zodiac RHIB	7	59.3	577	26	663	9	na	0.5	10	3	na	na	na	na	na
N/NPS	C	18-23 June 2011	Zodiac RHIB	5	46.1	561	43	936	10	na	0.5	5	3	na	na	na	na	na
	C	deployed under SCORE funding, not SCORE field time	Zodiac RHIB	0	0	0	0	0	0	0	0	0	4	na	na	na	na	na
N	Si	4-11 Jan 2011 SCI-M3R	RHIB-Si	8	57.5	550	34	2,371	8	2,791	1	6	na	8	0.75	na	4	na
N	Si	1-7 May 2011 SCI-M3R	RHIB-Si	7	56.1	558	42	4,476	8	2,831	1	11	na	14	1.45	na	4	na
N	Si	21-25 July 2011 SCI-M3R	RHIB-Si	5	40.1	396	31	2,902	5	1,612	1	5	na	8	0.3	na	4	na
N	Si	02 August 2010 - 30 July 2011 SIO/SWFSC bimonthly San Diego coastal surveys	RHIB-Si	19	111	795	118	6,150	7	8,753	na	6	na	15	1.5	na	4	na
N	Si	30 July 2010 - 26 April 2011 Four CalCOFI cruises	SHIP-Si/NOAA	76	455	3,813	268	13,399	14	2,600	na	na	na	113	872	344	11	221
Totals:				161	1001	21,196	1,225	100,594	117	21,524	18.8	44	14	158	876	344	27	221

Visual Surveys (Aerial Summary)

Under terms and conditions of the Navy's Year Three 01 August 2010 to 02 August 2011 Monitoring Plan, the Navy completed 1,001 hours of visual surveys out of a planned 100-150 hours. Of the 1,001 hours of visual survey effort, aerial visual surveys accounted for 127.4 hours (**Table S-3**). Aerial visual surveys provide the opportunity to rapidly survey large tracks of ocean in the fraction of time needed by ship based surveys, although on-station time is typically limited by the amount of fuel available aboard a given airplane. Typical on-station survey times for a single flight were around 3-5 hours for a civilian airplane (Partenavia P-68-C or P-68-OBS or Twin Commander 685). While all visual survey effort is presented in **Table S-2** and **S-3**, specific aerial visual survey accomplishments in Year Three include: Completion of five aerial survey periods, a 28 hour airplane survey from 23-28 September 2010; a 17 hour airplane survey 14-19 February 2011; a 9.5 hour airplane survey from 29 March – 3 April 2011; a 46 hour airplane survey from 12-20 April 2011; and a 27 hour airplane survey from 9-14 May 2011. Some of these aerial surveys represented relatively rare winter marine mammal effort in Southern California, with the exception of the visual and passive efforts coming out of the Navy's research funded CalCOFI surveys (Appendix D).

- Over 13,240 nm surveyed
- 623 sighting of approximately 68,757 marine mammals
- 2,937 hi-resolution digital photos taken
- 14.3 hours of digital video taken

Completion of 71 focal follows greater than 5 min each of various marine mammals for total of 30.1 hours of detailed behavioral focal follows. SES 2011 report combines July 2010 and September 2010 field efforts (**Appendix B**). Only September 2010 effort is summarized in this report. The Navy's 2010 Monitoring Report (DoN 2010) contains the July 2010 field discussions. Aerial surveys within the Southern California Range Complex have a distinct contribution they can make to the overall monitoring plan. These kinds of surveys:

1. Provide advantage of surveying key Navy areas of interest within one day, providing a "snapshot" of marine mammal numbers, presence, distribution and behavior before, during and after major training events,
2. Collect quantifiable behavioral data known to be indices of stress/disturbance,
3. Conduct focal follows of priority cetacean species including video-documentation of underwater behavior,
4. Provide a platform from which behavior and potential reactions of cetaceans to Navy training may be studied without confounding results (vs. from vessels), and
5. Locate and identify dead floating or stranded marine mammals.

The Navy will continue to use aerial surveys in next year's monitoring for both spatial coverage, but more importantly to continue to gather baseline behavioral data on marine mammals at-sea. For instance, although compiled from just one survey (9-14 May 2011), **Figures S-3a and S-3b** show some of the basic observations, in this case for dolphins and whales, being obtained from aerial surveys in Southern California.

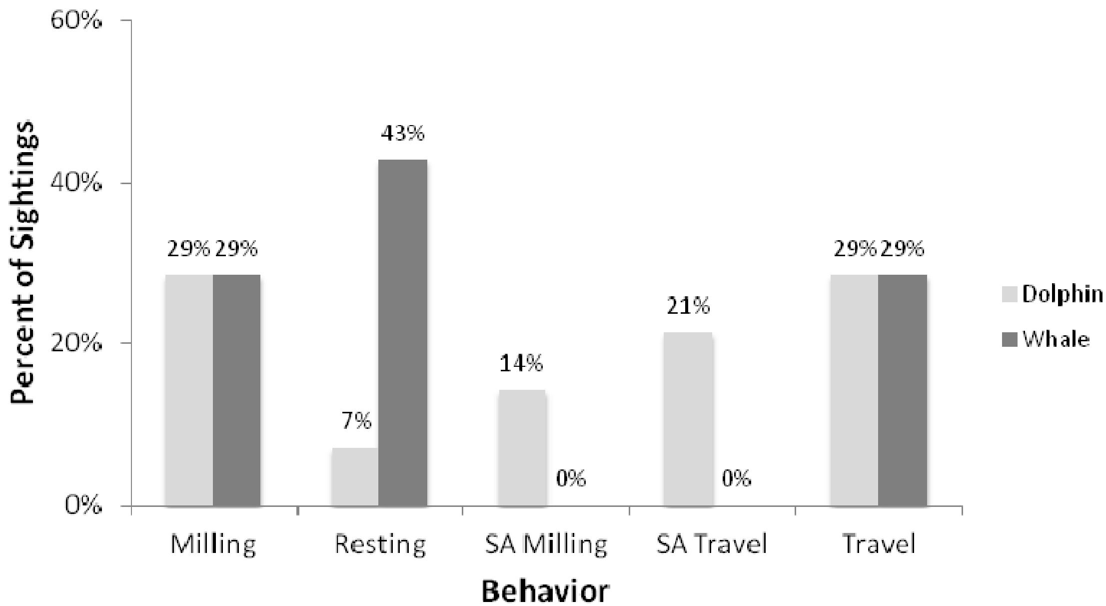


Figure S-3a. Frequency of initially observed behavioral states for dolphins and whales during May 2011 Southern California aerial survey. Note: SA = surface active.

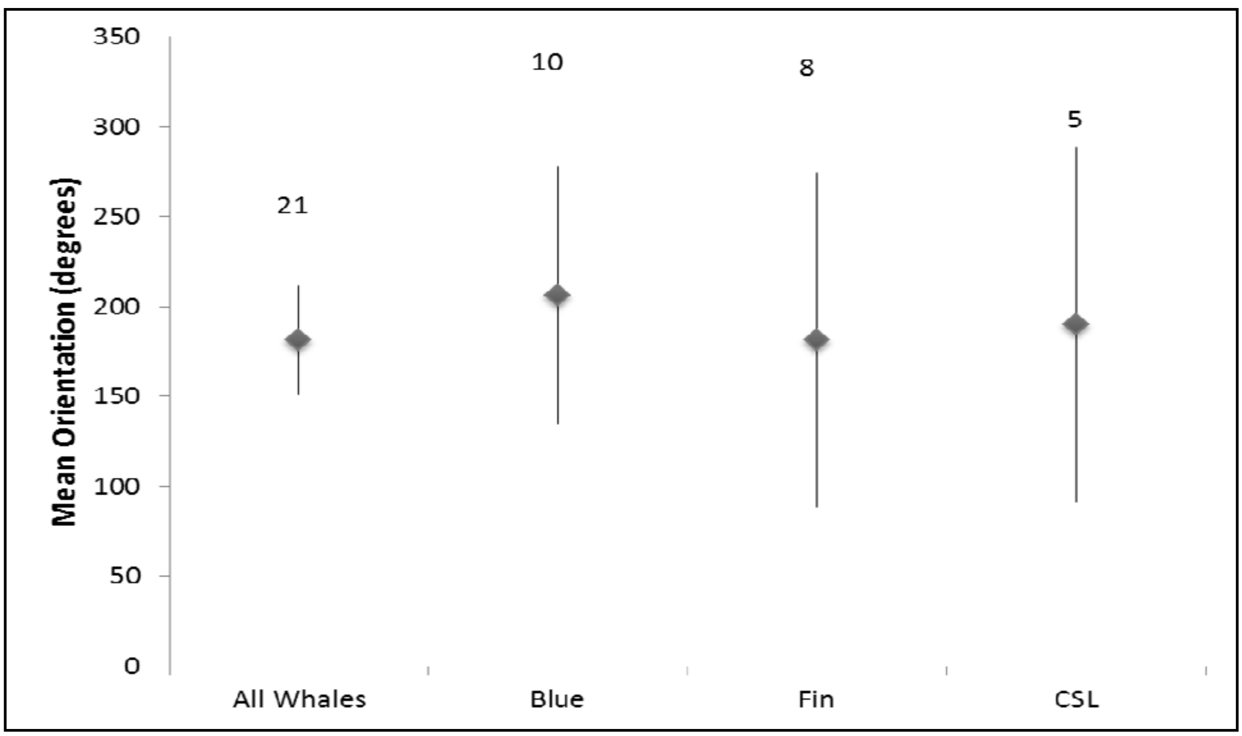


Figure S-3b. Mean and standard deviation of orientation/heading in degrees magnetic between nearest neighbors within a subgroup by whale and California sea lion (CSL) species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars.

The following photographs over the next few pages highlight some of the unique sightings within the Southern California Range Complex during Year Three.

For the first time since SOCAL aerial monitoring surveys began in fall 2008, sperm whales were seen (a group of 20 including 4 calves). They were associated with both Risso's dolphins and northern right whale dolphins. The sighting occurred on May 14, 2011 approximately 24 NM west of San Diego near the edge of an underwater ridge. A sperm whale (Physeter macrocephalus) nursery group was observed from the aircraft using a telephoto lens during the May 2011 aerial marine mammal monitoring survey off San Diego, California, demonstrating the ability to observe cetaceans and behavior sub-surface during an aerial survey. Photos by David Steckler courtesy of Smultea Environmental Sciences. The Navy had a major training exercise ongoing in the Southern California Range Complex on this day. However, in an analysis of ship positions and sonar use, the ships involved with the training were 30-50 nautical miles to the east of the sperm whale sighting location. San Clemente Island would have been between the two locations (the sperm whale site and Navy ship concentration). The nearest other Navy surface ship to the sighting was 30 nautical miles due south (i.e., not in the "shadow" of San Clemente Island), but was not using sonar at the time of the sighting or for the morning prior to the sighting time. At this time, it is unknown if the observation was an as yet, unseen natural behavior in response to foraging, predator avoidance, or some other natural phenomena, or a reaction to or avoidance of an anthropogenic event. This sighting highlights the importance of continuing to collect baseline marine mammal behavioral information to build the science on what could constitute normal behavior for marine mammal species.

(Top) Sperm whales mixed with northern right whale dolphins and Risso's dolphins; (Below) Risso's dolphin approaches another sperm whale from front. Note: sperm whale's open jaw.

Below is a photo from a rare (for Southern California) sighting of a Bryde's whale (Balaenoptera edeni/brydei) *observed on September 24, 2010 from the aircraft during the September 2010 aerial marine mammal monitoring survey off San Diego, California. Photograph taken by Bernd Würsig courtesy of Smultea Environmental Sciences.*

Below are photos from a sighting of two minke whales (Balaenoptera acutorostrata) *observed on September 24, 2010 from the aircraft during the September 2010 aerial marine mammal monitoring survey off San Diego, California. Photographs taken by Bernd Würsig courtesy of Smultea Environmental Sciences.*

Marine Mammal Observers

Under terms and conditions of the Navy's Year Three 01 August 2010 to 02 August 2011 Monitoring Plan, the Navy completed 83 hours of Marine Mammal Observers (MMO) out of a planned 50-100 hours of MMOs.

There was one MMO event in the Southern California Range Complex within Year Three. Four Navy civilian marine science biologists embarked on a Navy destroyer from 4 to 7 April 2011. The ship then proceeded to sea within the Southern California Range Complex where it engaged in various sonar and non-sonar training events during a planned unit-level training.

The following pages provide details for the April 2011 Southern California MMO event.

During the four-day MMO underway period, the MMOs made 24 sightings of approximately 599 marine mammals. In fact, the frequency of sightings when compared to MMO events on other Navy range complexes was such that the MMO team identified several study protocol and data recording procedure modifications needed to account for the faster rate of sighting marine mammals within Southern California. These changes will be incorporated into future MMO events within California.

Some of the analysis from this event will be folded into a Navy-wide lookout effectiveness study using MMO events on Navy ships along the Atlantic Coast, Hawaii, and Southern California. This pooled data study will be reported in later submissions to the National Marine Fisheries Service in the 2012-2013 timeframe.

Navy Lookout Effectiveness Study

The U.S. Navy undertakes monitoring of marine mammals during Navy exercises and has mitigation procedures designed to minimize risk to these animals. One key component of this monitoring and mitigation is the shipboard lookouts (LOs, also known as watchstanders), who are part of the standard operating procedure that ships use to detect objects (including marine mammals) within a specific area around the ship during events. The watchstanders are an element of monitoring requirements specified by NMFS in the MMPA Letters of Authorization. The goal is to detect mammals entering ranges of 200, 500 and 1000 yards around the vessel, which correspond to distances at which various mitigation actions should be performed. In addition to the lookouts, officers on the bridge search visually and SONAR operators listen for vocalizations during anti-submarine warfare training. We refer to all of these observers together as the "observation team" (OT). The aim of this study is to determine the OT effectiveness in terms of detecting and identifying marine mammals. Of particular interest is the probability of an animal getting within a defined range of the vessel without being observed by the OT, as well as determining the accuracy of the OT (primarily the LO) in determining species group (whale, dolphin, etc.) group size and position. In order to achieve this, experienced MMOs search and collect information on marine mammals that both they and the OT detect.

Work was previously conducted to design and test a protocol for determining the effectiveness of the LOs in visually detecting marine mammals. The field protocol for the experiments was developed in consultation with members of the Naval Undersea Warfare Center Division, Newport (NUWCDIVNPT); U.S. Fleet Forces Command; NAVFAC; Commander, U.S. Pacific

Fleet; and NMFS. The basic concept is that trained Marine Mammal Observers (MMOs) are situated on board a vessel during daylight at-sea exercises, in locations where they can watch for marine mammals and communicate with one another, but not cue the LO. The MMOs then work to set up opportunistic trials, where they detect a surfacing of a marine mammal at a measured location, and record whether that surfacing was also detected (a successful trial) or not (an unsuccessful trial) by the LO.

It was found to be necessary to have an additional "liaison" MMO (LMMO) stationed with the LO, and in communication with the other MMOs, to help report when and where LOs detected surfacings. It was also necessary to have an additional team member tasked solely with data recording. In addition to recording surfacing events, MMOs attempted to keep track of which surfacings belonged to the same school or animals. The revised protocol (Burt and Thomas 2010[8]) was applied to one further at-sea exercise (off Southern California), making four datasets in total.

In parallel with field protocol development, methods are being developed for using the data generated during these experiments to estimate the probability of animals entering the stand-off range undetected. An analysis method to allow for intermittent availability is also being developed, since many marine mammal species remain on (or close to) the surface for significant periods between dives, and so are "intermittently available" for detection. The extended methods currently only use information about the location of LO detections, but could conceivably be extended further to use information from the MMO LO trials. As a proof of concept both the instantaneous and intermittent availability models to data collected in the at-sea experiments will be applied.

Recommendations for future data collection efforts focus on a single vessel type and an area where the number of trials per cruise is likely to be maximized. Resources would be devoted to extending the intermittent availability models so that they use both the locations of observed animals and the outcomes of the MMO trials, thereby unifying the models developed to date for instantaneous and intermittent availability.

Major accomplishments related to this project to date include initial development of data collection protocols and analytic methods, data collection trials, completed a proof of concept for detection functions, consultation with NMFS technical staff for input on analysis methods, and investment in continued refinement of the analytic methods and focus on additional data collection in 2011/2012.

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

8 Burt, M.L. and Thomas, L. 2010. Calibrating US Navy lookout observer effectiveness. Information for Marine Mammal Observers. Version 2.1. Prepared for Department of the Navy.

APRIL 2011 CRUISE REPORT- MARINE SPECIES MONITORING & LOOKOUT EFFECTIVENESS STUDY DURING SOUTHERN CALIFORNIA UNIT LEVEL TRAINING EXERCISE DDG-E

Prepared by Ms. Morgan Richie, Naval Facilities Engineering Command – Pacific; Mr. Josh Frederickson, Naval Undersea Warfare Center, Newport; Mrs. Andrea Balla-Holden, Naval Facilities Engineering Command – Northwest; Dr. Thomas Jefferson, Clymene Enterprises

Introduction

The U.S. Navy undertakes monitoring of marine mammals during Navy exercises and has mitigation procedures designed to minimize risk to these animals. One key component of this monitoring and mitigation is the shipboard lookouts (LOs, also known as watchstanders), who are part of the standard operating procedure that ships use to detect objects (including marine mammals) within a specific area around the ship during events. The watchstanders are an element of monitoring requirements specified by NMFS in the MMPA Letters of Authorization. The goal is to detect mammals entering ranges of 200, 500 and 1000 yards around the vessel, which correspond to distances at which various mitigation actions should be performed. In addition to the lookouts, officers on the bridge search visually and SONAR operators listen for vocalizations during anti-submarine warfare training. We refer to all of these observers together as the "observation team" (OT). The aim of this study is to determine the OT effectiveness in terms of detecting and identifying marine mammals. Of particular interest is the probability of an animal getting within a defined range of the vessel without being observed by the OT, as well as determining the accuracy of the OT (primarily the LO) in determining species group (whale, dolphin, etc.) group size and position. In order to achieve this, experienced MMOs search and collect information on marine mammals that both they and the OT detect.

Work was previously conducted to design and test a protocol for determining the effectiveness of the LOs in visually detecting marine mammals. The field protocol for the experiments was developed in consultation with members of the Naval Undersea Warfare Center Division, Newport (NUWCDIVNPT); U.S. Fleet Forces Command; NAVFAC; Commander, U.S. Pacific Fleet; and NMFS. Trials were conducted during three at-sea exercises (one in Kauai and two in JAX; see DoN 2010 for details on the effectiveness studies conducted off JAX), and lessons learned from these trials resulted in the protocol being further refined. The basic concept is that trained Marine Mammal Observers (MMOs) are situated on board a vessel during daylight at-sea exercises, in locations where they can watch for marine mammals and communicate with one another, but not cue the LO. The MMOs then work to set up opportunistic trials, where they detect a surfacing of a marine mammal at a measured location, and record whether that surfacing was also detected (a successful trial) or not (an unsuccessful trial) by the LO.

It was found to be necessary to have an additional "liaison" MMO (LMMO) stationed with the LO, and in communication with the other MMOs, to help report when and where LOs detected surfacings. It was also necessary to have an additional team member tasked solely with data recording. In addition to recording surfacing events, MMOs attempted to keep track of which surfacings belonged to the same school or animals. The revised protocol was applied to one further at-sea exercise (off Southern California), making four datasets in total.

As part of the monitoring plan for the Southern California Range Complex Marine Mammal Protection Act compliance, four civilian marine mammal observers (MMOs) participated in a unit-level training exercise (ULT) from April 4-7, 2011. These MMOs were stationed aboard a U.S. Navy destroyer, hereafter referred to as DDG-E. The goals of the monitoring and this study were to:

1. Collect data to assess the effectiveness of the Navy lookout team.
2. Obtain data to characterize the possible exposure of marine species to mid-frequency active sonar (MFAS).

Shipboard Monitoring

MMO surveys were conducted on a not-to-interfere basis, which means that the MMOs would not replace required Navy lookouts, would not dictate operational requirements/maneuvers, and would remove themselves from the bridge wing if necessary for DDG-E to accomplish its training objectives. The exceptions would be if a marine mammal was sighted by the MMO within the shut-down mitigation zone during mid-frequency active sonar (MFAS) use (200 yards [yds], 183 meters [m]) and was not seen by the Navy lookout team, or if the vessel was in danger of striking a marine species. In these cases, the MMO would report the sighting to the Navy lookout team for appropriate reporting and action.

The MMO survey on DDG-E was conducted on the bridge wings (elevated 66 feet [ft; 20 m] above the waterline), with two MMOs actively searching for marine mammals, one MMO recording data, and one MMO acting as a liaison with the bridge team/lookouts to relay their sightings. While on effort, MMOs used naked eye and 7 X 50 magnification binoculars to scan the area from dead ahead to just aft of the beam.

Results

Shipboard Monitoring

Effort and environmental information was collected when the MMOs began effort, at each rotation, and as significant weather changes occurred. The MMO team spent 20 hours 57 minutes, and 05 seconds searching for marine species during the exercises (**Table 1).**

Table 1. Effort Hours and Environmental Conditions

Date	Team Hours On-Effort	Beaufort Sea State (range)	% Cloud Cover (range, conditions)	Visibility
4 April	2.23	3-4	5% - 100%	Moderate -Good
5 April	7.32	2-5	40%-100%	Poor – Moderate
6 April	8.07	4-5	100%	Poor - Moderate
7 April	3.33	3-5	40%-100%	Moderate
Total	**20.95**	**2-5**	**5%-100%**	**Poor – Good**

For all four observers, a total of 83 hours, 48 minutes, and 20 seconds of marine mammal shipboard monitoring was conducted. Beaufort Sea States ranged from 2 to 5, with the majority of the time occurring in Sea States 4 – 5. The Beaufort Sea State was a 6 for 1 hour and 32 minutes on 4/6/2011, and the team went off effort (**Figures 1 and 2**). The majority of effort was conducted in an area south of San Clemente Island (**Figure 3**).

In total, 24 sightings of marine mammals including 23 sightings of cetaceans, one sighting of a pinniped, and zero sightings of turtles were recorded during the four days of observation (**Table 4**). Nineteen of the sightings were made independently by the MMOs, that is, not seen by the Navy lookout team. However, it should be noted that there was no MFAS being used at these sighting times, so Navy lookout responsibility during non-MFAS steaming and training is for sighting of marine mammal for near-ship collision avoidance vice mitigation at ranges < 1000 yards (914 m). Additionally, two sightings were made by the Navy lookout team, but were not sighted by the MMOs. Three sightings were sighted by both the MMOs and Navy lookout team (**Table 2**). Four sightings were identifiable to species; one sighting of long-beaked common dolphins (*Delphinus capensis*), one sighting of Risso's dolphins (*Grampus griseus*), one sighting of a Minke whale (*Balaenoptera acutorostrata*), and one sighting of a California sea lion (*Zalophus californianus*) (**Table 3**).

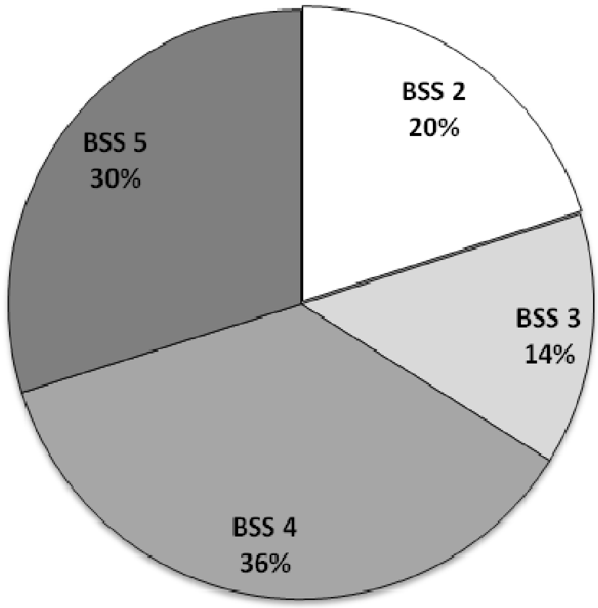


Figure 1. Total Percentage of Effort at Beaufort Sea States

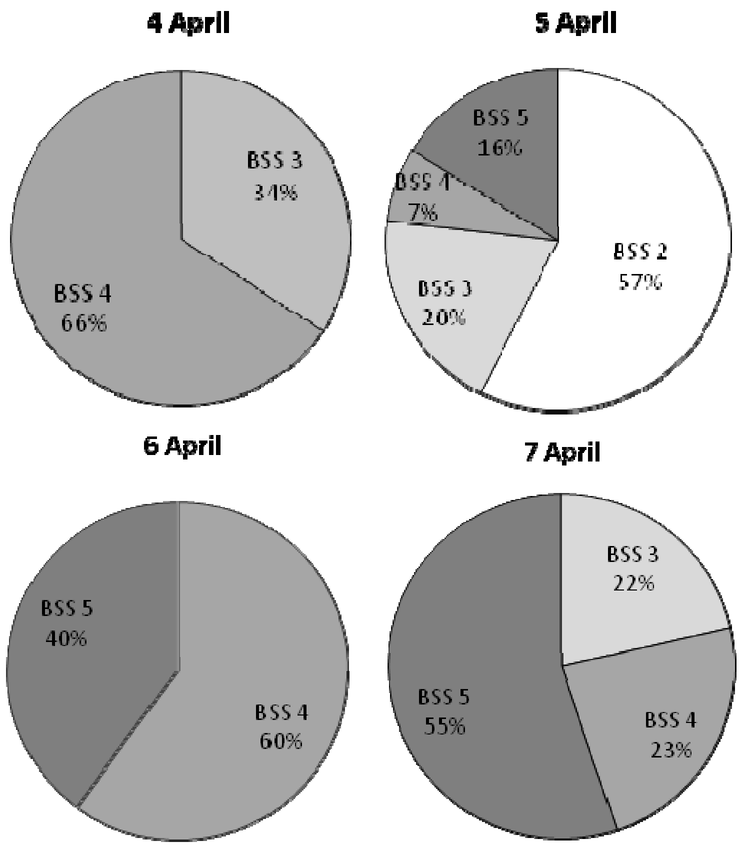


Figure 2. Daily percentage of effort at Beaufort Sea State

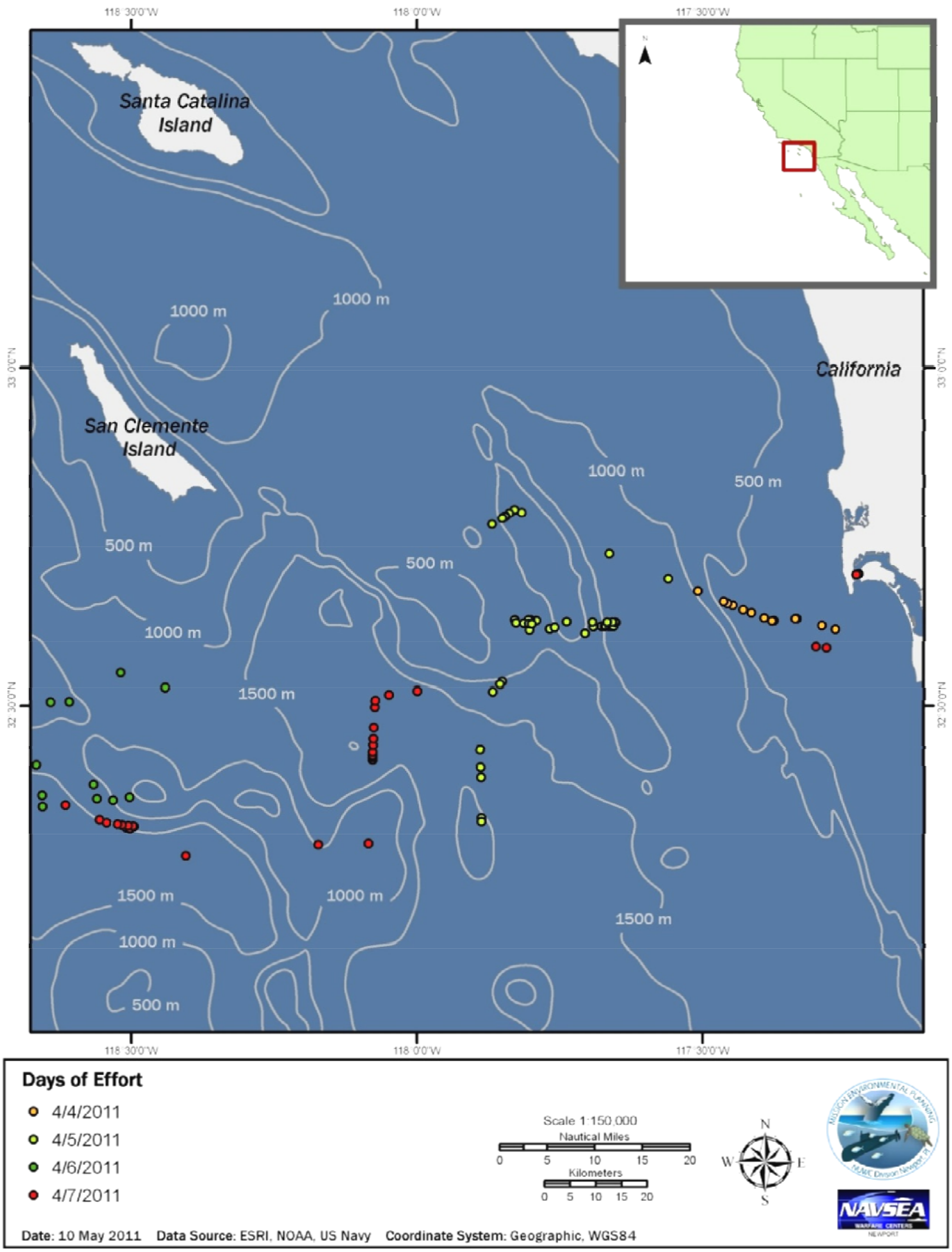


Figure 3. Location of MMO Effort April 2011.

Table 2. Marine Mammal and Sea Turtle Sightings by Observer

Date	Independent MMO Sightings	Independent Navy Lookout Team Sightings	Sightings by both Teams
4 April	9	0	1
5 April	6	0	2
6 April	2	0	0
7 April	2	2	0
Total	**19**	**2**	**3**

Table 3. Unique sightings by species

Species	Unique animal group sightings	Total number of animals (based on best group size estimate)
Long-beaked common dolphin	1	15
Risso's dolphin	1	12
California Sea Lion	1	1
Minke whale	1	1
Delphinus species	7	528
Unidentified dolphin	4	32
Unidentified balaenopterid	4	5
Unidentified whale	5	5
Total	**24**	**599**

Table4. Marine Mammal and Sea Turtle Sightings

Data Category	Sighting 1	Sighting 2	Sighting 3	Sighting 4	Sighting 5	Sighting 6	Sighting 7
Sightings Information							
Effort (on/off)	On	On	On	On	On	On	On
Date	4/4/2011	4/4/2011	4/4/2011	4/4/2011	4/4/2011	4/4/2011	4/4/2011
Time	155031	155031	160224	160309	161302	161751	162416
Location	32.61883 117.29227	32.61883 117.29227	32.62902 117.33572	32.62895 117.33847	32.62587 117.37580	32.62998 117.39310	32.63765 117.41520
Detection Sensor	MMO	MMO	MMO	MMO	MMO	MMO	MMO
Species/Group	Long-beaked common dolphins	California sea lion	Unidentified Delphinus spp	Unidentified Delphinus spp	Unidentified Delphinus spp	Unidentified whale	Unidentified balaenopterid
Group Size (min/max/best)	10/15/15	1/1/1	30/48/39	52/107/78	9/22/16	1/1/1	1/2/1
# Calves							
Bearing (rel)	270	120	315	90	315	350	300
Distance (m)	20	50	1009	2343	896	2755	3350
Environmental Information							
Wave height (ft)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Visibility	Good	Good	Good	Good	Good	Good	Good
BSS	4	4	4	4	4	4	4
% cloud cover	p0% s5%	p0% s5%	p0% s5%	p0% s5%	p0% s5%	p0% s5%	p0% s5%
% glare	P35% s10%	P35% s10%	P35% s10%	P35% s10%	P35% s10%	P35% s10%	P35% s10%
Operational Information							
Sonar on/off	Off	Off	Off	Off	Off	Off	Off
Ship bearing (true)	287	287	265	265	295	295	295
Animal motion	Parallel	None			Closing	None	None
Sighting Cue/ Behavior	Body	Body	Splash	Birds	Body	Blow	Blow
Mitigation implemented	None	None	None	None	None	None	None
Comments	Photos taken (#014-119, blank 120)		Dolphins. Photos 121-131				Nearby dolphins detected passively by ship sonar

Table 4 (Con't). Marine Mammal and Sea Turtle Sightings

Data Category	Sighting 8	Sighting 9	Sighting 10	Sighting 11	Sighting 12	Sighting 13	Sighting 14
Sightings Information							
Effort (on/off)	On	On	On	On	On	On	On
Date	4/4/2011	4/4/2011	4/4/2011	4/5/2011	4/5/2011	4/5/2011	4/**5**/2011
Time	163334	165107	190929	083936	084600	084951	090002
Location	32.64868 117.44798	32.66982 117.50903	32.77982 117.84490	32.61803 117.67770	32.61793 117.66380	32.61808 117.65680	32.62382 117.65417
Detection Sensor	MMO	MMO	MMO	MMO	MMO	MMO	MMO
Species/Group	Unidentified dolphin	Unidentified balaenopterid	Minke whale	Unidentified dolphin	Delphinus spp	Delphinus spp	Delphinus spp
Group Size (min/max/best)	7/12/9	1/1/1	1/1/1	4/13/7	1/1/1	1/1/1	65/475/294
# Calves							
Bearing (rel)	275	290	315	270	290	315	0
Distance (m)	1009	2041	2755	2041	2041		2041
Environmental Information							
Wave height (ft)	Moderate	Light	Light	Light	Light	Light	Light
Visibility	Good	Good	Good	Good	Good	Good	Good
BSS	4	4	3	2	2	2	2
% cloud cover	p0% s5%	p0% s 0%	p15% s5%	p100% s100%	p100% s100%	p100% s100%	p100% s100%
% glare	P35% s10%	P 35% s 0%	p45% s0%	p0% s0%	p0% s0%	p0% s0%	p0% s0%
Operational Information							
Sonar on/off	Off	Off	Off	Off	Off	Off	Off
Ship bearing (true)	295	295	315	90	90	90	90
Animal motion	Closing	None	Parallel	Parallel	Closing	Closing	Closing
Sighting Cue/ Behavior	Body	Blow	Splash	Splash, body	Splash	Body	Body
Mitigation implemented	None	None	None	None	None	None	None
Comments	Passed beam		Minke breached 3 times	Passed abeam at 0843		Second sighting by crew member, did not give bearing or distance. LO asked bridge to log sighting.	Bridge crew called them "seals." Some closed to bowride. Pod was spread out.

Table 4 (Con't). Marine Mammal and Sea Turtle Sightings

Data Category	Sighting 15	Sighting 16	Sighting 17	Sighting 18	Sighting 19	Sighting 20	Sighting 21
Sightings Information							
Effort (on/off)	On	On	On	On	On	On	On
Date	4/5/2011	4/5/2011	4/5/2011	4/5/2011	4/6/2011	4/6/2011	4/7/2011
Time	100125	102917	103402	130510	081115	181651	084249
Location	32.62638 117.79150	32.62298 117.82722	32.62198 117.81320	32.53147 117.85460	32.38283 118.69468	32.31875 118.50855	32.41910 118.07755
Detection Sensor	MMO	MMO	MMO	MMO	MMO	MMO	MMO
Species/Group	Risso's dolphin	Unidentified whale	Unidentified dolphin	Unidentified dolphin	Unidentified whale	Delphinus spp	Unidentified balaenopterid
Group Size (min/max/best)	6/20/12	1/1/1	4/7/5	5/10/8	1/1/1	50/225/93	2/2/2
# Calves							
Bearing (rel)	38	290	300	358	30	3	45
Distance (m)	1154	4298	2041	4298	4298	3350	3350
Environmental Information							
Wave height (ft)	Light	Light	Light	Light	Moderate	Moderate	Light
Visibility	Good	Good	Good	Good	Poor	Moderate	Moderate
BSS	2	2	2	3	4	4	3
% cloud cover	p100% s100%	p80% s80%	p80% s80%	p50% s50%	p100% s100%	p100% s100%	p100% s98%
% glare	p0% s0%	p25% s0%	p25% s0%	p15% s20%	p0% s0%	p0% s0%	p0% s1%
Operational Information							
Sonar on/off	Off	Off	Off	Off	Off	Off	Off
Ship bearing (true)	270	100	94	224	309	104	0
Animal motion	Closing, parallel		Parallel	Closing	None	Closing	Closing
Sighting Cue/ Behavior	Body	Blow	Body	Body	Blow	Dorsal fin	Blow
Mitigation implemented	None	None	None	None	None	Yes	None

Data Category	Sighting 15	Sighting 16	Sighting 17	Sighting 18	Sighting 19	Sighting 20	Sighting 21
Operational Information (continued)							
Comments	Turned to move parallel to the ship, toward the stern			Not a trial – went off effort due to potential radio interference with ammunition		1821 informed bridge (waypoint #82). Animals were outside the mitigation zone; - ship and animals were closing on each other. Gunnery Exercise secured and ship changed course as a precaution.	

Table 4 (Con't). Marine Mammal and Sea Turtle Sightings

Data Category	Sighting 22	Sighting 23	Sighting 24
Effort (on/off)	On	On	On
Date	4/7/2011	4/7/2011	4/7/2011
Time	173349	091208	091539
Location	32.42635 118.07703	32.49780 118.07327	32.50735 118.07253
Detection Sensor	LO	LO	MMO
Species/Group	Unidentified whale	Unidentified whale	Unidentified balaenopterid
Group Size (min/max/best)	1/2/1	1/1/1	1/1/1
# Calves			
Bearing (rel)	90	300	300
Distance (m)		2755	2000
Environmental Information			
Wave height (ft)	Light	Moderate	Moderate
Visibility	Moderate	Moderate	Moderate
BSS	3	4	4
% cloud cover	p100% s98%	p70% s90%	p70% s90%
% glare	p0% s1%	p0% s5%	p0% s5%
Operational Information			
Sonar on/off	Off	Off	Off
Ship bearing (true)	0	0	0
Animal motion	Closing	None	None
Sighting Cue/Behavior	Blow	Blow	Blow
Mitigation implemented	None	None	None
Comments	LO did not give estimate of distance	Distance estimated by MMO	

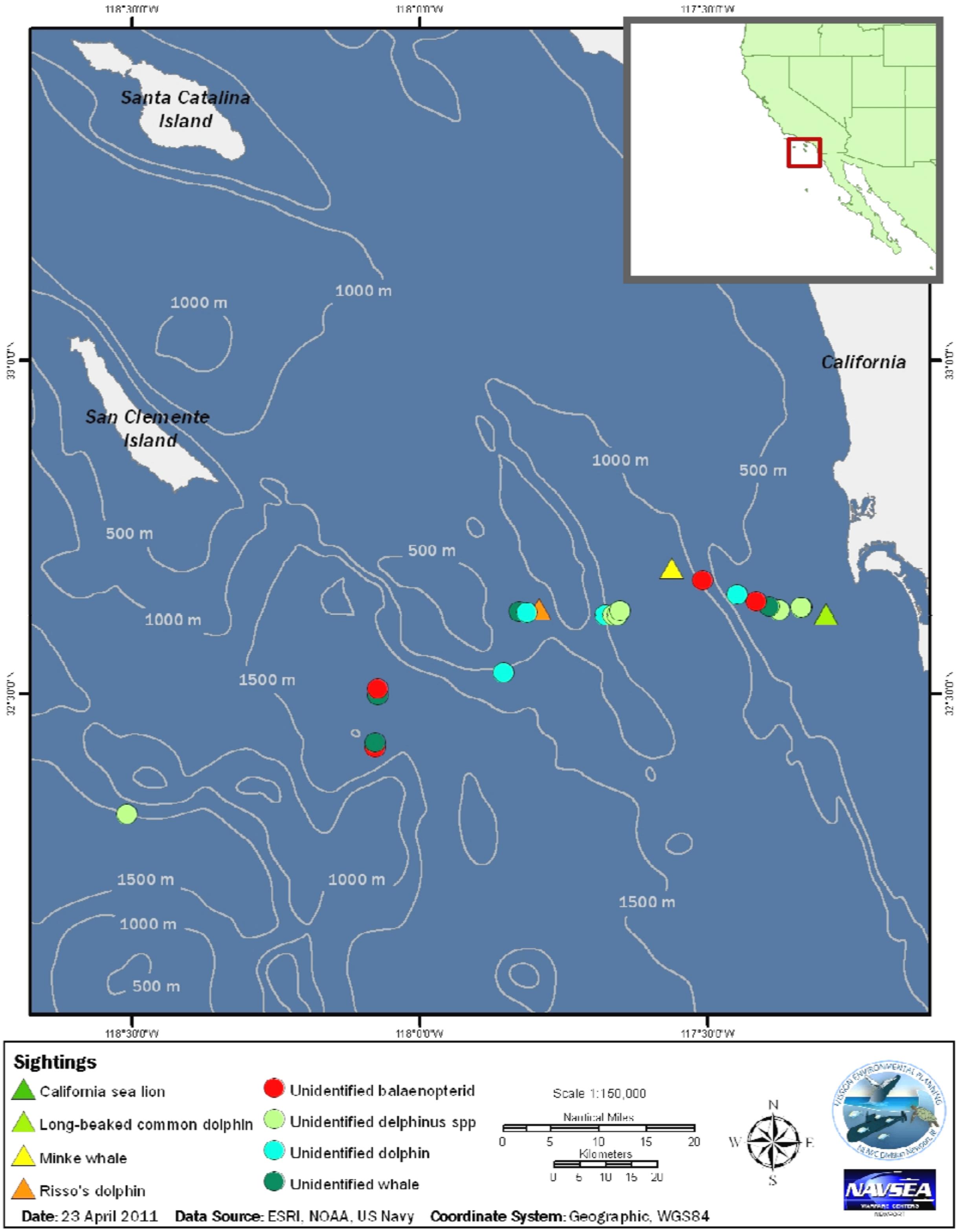


Figure 4. Marine mammal sighting locations during MMO embark of April 2011

Nineteen of the sightings (79%) were considered trials for the lookout effectiveness study. Trials were conducted on all days of the study, for an average rate of .91 trials per hour across all four days (**Table 4**).

Table 5. Effort Hours, Sighting Rates, and Trial Rates

Date	Hours MMO Team Effort	# of Unique Sightings*	Sightings/ Hour	# of Trials	Trials/Hour
4/4/2011	02:13:46	10	4.49	8	3.59
4/5/2011	07:19:27	8	1.09	7	.96
4/6/2011	08:04:19	2	.25	2	.25
4/7/2011	03:19:33	4	1.2	2	.6
Total	**20:57:05**	**24**	**1.15**	**19**	**.91**

Conclusions

In parallel with field protocol development, methods are being developed for using the data generated during these experiments to estimate the probability of animals entering the stand-off range undetected. An analysis method to allow for intermittent availability is also being developed, since many marine mammal species remain on (or close to) the surface for significant periods between dives, and so are "intermittently available" for detection. The extended methods currently only use information about the location of LO detections, but could conceivably be extended further to use information from the MMO LO trials. As a proof-of-concept, both the instantaneous and intermittent availability models to data collected in the at-sea experiments, will be applied.

Recommendations for future data collection efforts focus on a single vessel type and an area where the number of trials per cruise is likely to be maximized. Resources would be devoted to extending the intermittent availability models so that they use both the locations of observed animals and the outcomes of the MMO trails, thereby unifying the models developed to date for instantaneous and intermittent availability.

Major accomplishments related to this project to date include initial development of data collection protocols and analytic methods, data collection trials, completed a proof of concept for detection functions, consultation with NMFS technical staff for input on analysis methods, and investment in continued refinement of the analytic methods and focus on additional data collection in 2011/2012.

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

SECTION 3 SELECT PHOTOGRAPHS FROM DDG-E DURING APRIL 2011 EMBARK

Figure 5. MMOs embarked on DDG-E April 2011

(Top four pictures: visual survey from ship bridge wings; Bottom two pictures: data collection, recording and entry)

Figure 6. Ship photos taken with permission during DDG-E training in SOCAL April 2011

Top picture: ship underway at-sea; Bottom left picture: prepare .50 cal M2 and 7.62mm M240 machine guns for gunnery exercise (GUNEX); Bottom right picture: bullet splashes from machine gun GUNEX.

Figure 7. Photos of various marine species during April MMO embark

Top left: Long-beaked common dolphin (*Delphinus capensis*); Top right: unidentified common dolphins near ship's bow; Bottom left: bow-riding common dolphins; Bottom right: ocean sun fish (*Mola mola*)

Passive Acoustic Monitoring

Under terms and conditions of the Navy's Year Three 01 August 2010 to 02 August 2011 Monitoring Plan, the Navy continued deployment of two bottom mounted passive acoustic monitoring (PAM) devices within the Southern California Range Complex (**Figure S-4**).

Two high-frequency acoustic recording packages (HARP) remained deployed this reporting period, and analyzed by the Whale Acoustic Lab, Marine Physical Laboratory of Scripps Institute of Oceanography (Dr. John Hildebrand) (http://cetus.ucsd.edu/). The HARP records broadband acoustic data (10 Hz – 100 kHz), including both marine species sounds and anthropogenic sounds. One HARP is located southwest of San Clemente Island near the eastern slope of the East Cortes Basin. The other HARP is located just north of the Southern California Range Complex northern boundary, northwest of San Clemente Island in the southern part of the Santa Cruz Basin (**Figure S-4**).

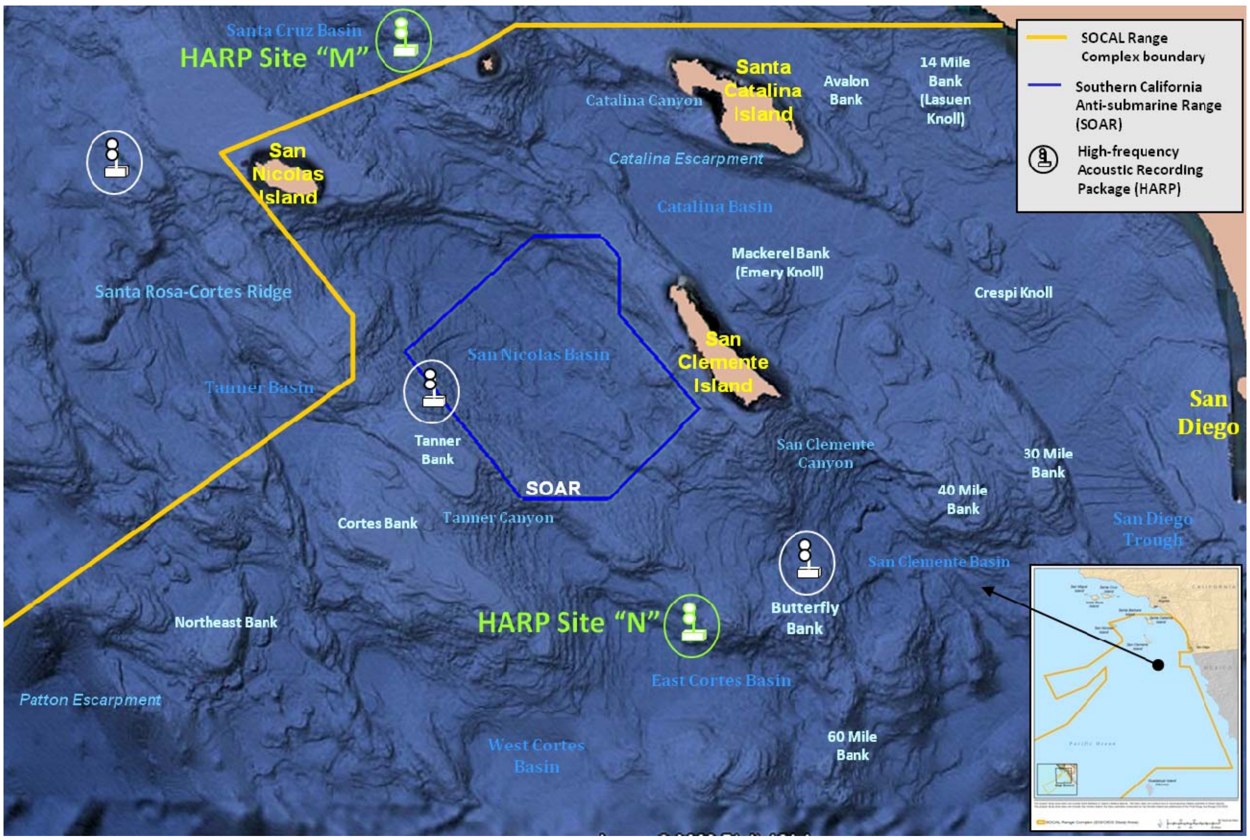


Figure S-4. Map of Navy funded bottom mounted high-frequency acoustic recording packages (HARPs) deployed within or adjacent to the Southern California Range Complex.

(HARPs "M" and "N" are funded by U.S. Pacific Fleet and data results reported here)

Preliminary analysis of these two HARPs for the time period April 2010 to April 2011 is contained in **Appendix C**. The reporting period of April to April is based on service time required for the HARPs (retrieve HARP, gather data, re-deploy HARP), and to allow analysis time for inclusion within **Appendix C**.

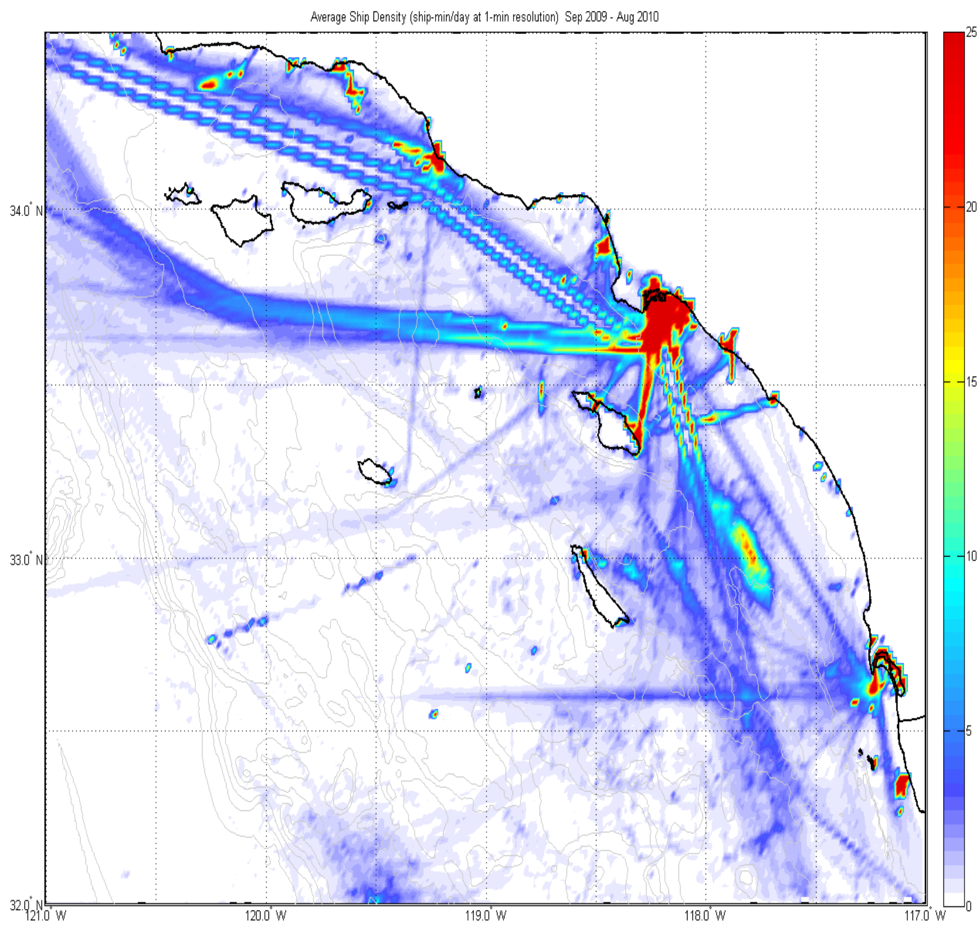
While **Appendix C** contains PAM results from the two Navy compliance monitoring funded PAM devices, it should be noted that substantial amounts of additional passive acoustic data were also collected this past year for Navy research funded HARPs both within and outside of the Southern California Range Complex (see **Figure S-4**). Analysis of data from these other HARPs, which are sometimes shifted in location within Southern California, are ongoing and not contained in this report.

Specific HARP PAM highlights accomplished in Year Three include:

- Passive acoustic monitoring was conducted at two sites in the Navy's Southern California Range Complex during April 2010 – April 2011. These data provide information on the presence of marine mammals and anthropogenic sound sources. High-frequency acoustic recording packages documented sounds between 10 Hz and 100 kHz with nearly continuous temporal coverage at a site near Santa Barbara Island (site M) and a site south of San Clemente Island (site N). Data analysis methods consisted of analyst scans of long-term spectral averages and spectrograms. The data were divided into three frequency bands and each band was analyzed for the sounds of marine mammal species or anthropogenic sources. Representative sounds are presented.
- Six baleen whale species were recorded: blue whales, fin whales, Bryde's whales, gray whales, humpback whales, and minke whales. Site N has more calling baleen whales than site M, as blue, fin, humpback, and Bryde's whale calls were all detected during more hours at site N. However, gray whale calls were detected only at site M. Pinniped barks, presumably made by California sea lions, were recorded during just a single week and only at site M. The largest number of odontocete detections by echolocation clicks and whistles were attributed to "unidentified dolphin" which is primarily comprised of short- and long-beaked common dolphins as well as bottlenose dolphins. Unidentified dolphins were detected throughout the year with a peak acoustic activity in late summer and fall months. Overall numbers of detections were slightly higher at site N than M. There was a distinct diel acoustic activity likely due to nighttime foraging, which was more apparent for click and less for whistle detections. Risso's dolphin echolocation clicks occurred throughout the year with increased detections in winter and early spring at site M. They were generally more frequent at site M than N. Two kinds of Pacific white-sided dolphin echolocation clicks were detected: Type A were present more often at site N and with higher numbers of detections at night indicating nighttime foraging, whereas type B were overall very seldom with highest detections at site M and a higher rate of detections during daytime. Sperm whale echolocation clicks were distributed throughout the year with more frequent detections at site M. Cuvier's beaked whales were detected throughout the year at both sites with higher numbers of occurrences at site N. A few detections were made of Baird's beaked whale and Stejneger's beaked whale, as well as two unidentified beaked whales with peak echolocation signal frequencies at 43 kHz and 50 kHz.
- Ship noise was the most common anthropogenic noise at both sites M and N. Both sites had Mid-Frequency Active (MFA) sonar events throughout the period April 2010 – April

2011. At site N, over 55,000 MFA sonar pings were detected ranging from 105 to 170 dB pp re 1 μPa. While site M had MFA sonar events recorded, the received levels and the number of pings were often much lower (e.g. < 120 dB pp re 1 μPa and 10's of pings/event) than at site N. Echosounder pings with a variety of primary frequencies (8 – 80 kHz) were found at both sites M and N. More echosounders were present at site M than at site N. Explosions were recorded at both sites up to 40 hours per week.

In contrast to military ship traffic, Southern California including portions of the Southern California Range Complex lie along major shipping routes to and from South America, and from the port of San Diego to Japan and Hawaii. **Figure S-5**, provided by the Naval Postgraduate School in Monterey CA, shows average commercial ship density within Southern California for the period of September 2009 to August 2010.



(Graphic courtesy of J. Joseph, Naval Postgraduate School, Ocean Acoustics Lab)

Figure S-5. Average commercial ship density in Southern California based on analysis on cumulative Automatic Identification System (AIS) data from September 2009 to August 2010.

Major Training Exercise Summary

For the eleven major training exercises conducted in the Southern California Range Complex this reporting period (02 Aug 2010 to 01 Aug 2011), the Navy conducted over 9,755 hours of Marine Species Awareness Training for 7,537 Navy personnel prior to beginning the training exercise. In addition, over the 134 non-consecutive major training exercise days in this same period (Table S-4), the Navy performed over 86,871 hours of visual observation (when counting the number of individual watchstanders engaged in lookout or navigation duties times the number of ships involved times the number of days at-sea).

Table S-4. SOCAL Range Complex major training exercises that occurred between 02 August 2010 and 01 August 2011.

MTE Type	Dates	# of Days	# of Ships Involved	# of Marine Mammal Sightings	# of Marine Mammals
C2X	23 JUL - 12 AUG 2010 *	11	10	77	1,049
SUSTEX	5 AUG - 20 AUG 2010	16	5	40	541
IAC	31 AUG - 2 SEP 2010	3	7	15	131
IAC	20 OCT - 22 OCT 2010	3	5	29	1,184
C2X	25 OCT - 15 NOV 2010	22	5	68	1,121
C2X	4 NOV - 19 NOV 2010	21	4	3	261
C2X	30 NOV - 20 DEC 2010	21	7	69	488
JTFEX	4 FEB - 9 FEB 2011	6	8	8	195
IAC	18 FEB - 20 FEB 2011	3	7	11	211
C2X	6 MAY - 27 MAY 2011	22	11	69	413
JTFEX	3 JUN - 8 JUN 2011	6	8	39	254
Total		**134**	**77**	**428**	**5,848**

Note: * This exercise was conducted over two reporting periods (2010 Monitoring Report and 2011 Monitoring Report). The data shown in this table reflects only the numbers from this reporting period (2011).

Key: C2X= Composite Training Unit Exercise; IAC= Integrated Anti-submarine Warfare Course; JTFEX= Joint Task Force Exercise; SUSTEX= Sustainment Exercise

SOCAL Range Complex Major Training Exercise Marine Mammal Observations

There were approximately 428 sightings of an estimated 5,848 marine mammals over the course of eleven major training exercises in the Southern California Range Complex. Breakdown of sightings by species type are shown in **Table S-5** and **Figure S-6**.

Dolphin species in Southern California typically occur in larger pods than whales, hence the higher number of dolphins and larger percentage of total numbers seen in these counts.

Table S-5. Total number of marine mammal sightings observed from Navy platforms during SOCAL Range Complex major training exercises 02 August 2010 to 01 August 2011.

Species Type	# of sightings	% of total sightings	# of marine mammals	% of total number of marine mammals
Dolphins	171	40%	5,255	90%
Whales	223	52%	435	7%
Pinnipeds	20	5%	136	2%
Not recorded	13	3%	22	1%
Totals:	**428**		**5,848**	

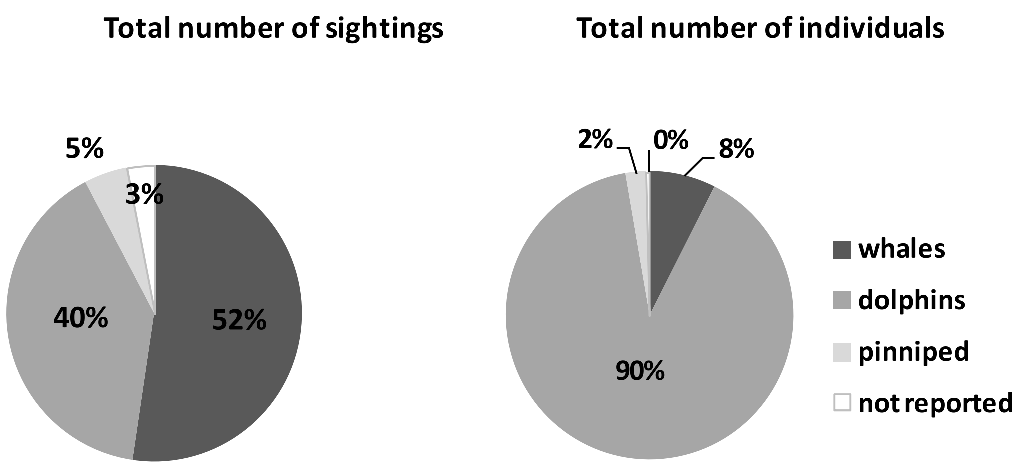


Figure S-6. Chart of marine mammal sightings (left) and number of individuals by species categories (right) during SOCAL Range Complex major training exercises 02 August 2010 to 01 August 2011.

SOCAL Range Complex Major Training Exercise Mitigations

From Table S-5, of the 428 Navy marine mammal sightings during major training exercises this reporting period, there were 110 sightings within 1,000 yards that qualified as mitigation exercises. In other words, mid-frequency active sonar units had their sonar on, and followed the appropriate mitigation (secure or power down) depending on the range to the marine mammal. There were 59 sonar shutdowns at ranges <200 yards (Table S-6), and 51 sonar powerdowns at ranges between 200-1,000 yards.

There were also 12 instances of Navy ships actively maneuvering to avoid marine mammals. Of these 12 maneuvers, 10 were to avoid whales (n=14 whales), and 2 were to avoid pods of dolphins (one pod of 30 and another of 200).

Table S-6. Number of marine mammal sightings at ranges less than 200 yards observed from Navy platforms during major training exercises concurrent with sonar shutdown mitigation 02 August 2010 to 01 August 2011.

Shutdown mitigation range	Total # of sightings	Total # of marine mammals	Breakdown by species type			
			# of whales	# of dolphins	# of pinnipeds	# of not reported
< 200 yards	59	890	28 times for 41 whales	24 times for 838 dolphins	4 times for 4 pinnipeds	3 times for 7 individuals

SUMMARY: Mitigation Effectiveness and Navy Safety Zone Adherence

During this year's major training exercises in the Southern California Range Complex, proscribed NMFS safety zones were effectively applied greater than 99% of the time in cases of observation of marine mammals within the applicable safety zone. There was only one instance of a ship powering down vice turning sonar off when a group of 10 dolphins were sighted at a 200-yard range. There were 9 instances this reporting period of bowriding dolphins. As detailed in previous Monitoring Reports, there is no sonar powerdowns or shutdowns in the case of bowriding dolphins.

The three categories of mitigation measures (Personnel Training, Lookout and Watchstander Responsibility, and Operating Procedures) outlined in the SOCAL Final Environmental Impact Statement/Overseas Environmental Impact Statement of December 2008 and approved by NMFS in subsequent Letters of Authorization in 2009, 2010 and 2011 were effective in appropriately mitigating exposure of marine mammals to mid-frequency sonar. During this year's major training exercises, the proscribed NMFS safety zones were adhered to, and vessels and aircraft applied mitigation measures when marine mammals were visually observed within the requisite zone. Fleet commanders, aircrews and ship watch teams continue to improve individual awareness and enhance reporting practices. This improvement can be attributed to the various pre-exercise conferences, mandatory Marine Species Awareness Training, adherence to required

MFAS mitigation zones, and application of lessons learned in marine mammal sighting and reporting.

Other Navy Funded Research

Navy research funded monitoring and marine mammal science within the Southern California Range Complex included several visual survey efforts, marine mammal tagging, and other relevant topics.

Specific field reports are included in **Appendix D** of this report, and include:

- Scripps Institute of Oceanography and National Marine Fisheries Service Southwest Fisheries Science Center small boat based marine mammal surveys in Southern California: Report of Results for August 2010 - July 2011
- Marine mammal surveys conducted during regularly scheduled California Cooperative Oceanic Fisheries Investigation (CalCOFI) field cruises within Southern California
- Cascadia Research Collective small vessel surveys and satellite tagging of marine mammal at SCORE[9] and surrounding areas of Southern California in 15 June[10] 2010- and 24 June 2011

Scripps Institute of Oceanography and National Marine Fisheries Service, Southwest Fisheries Science Center small boat surveys in Southern California

Primary objectives of this research is to use sighting, photo-identification, biopsy and acoustical sampling techniques to assess the occurrence, distribution and population structure of small cetaceans in a region that is subject to frequent naval exercises. Surveys are conducted from a 6.8 m rigid-hulled inflatable boat (RHIB). Survey effort is focused on the Southern California Offshore Range (SCORE) near San Clemente Island as part of an ongoing collaborative study to assess cetacean populations occurring in this active Navy training area. Additional surveys were conducted at peripheral locations including Catalina Island and the San Diego coastline. This geographically broad approach was designed to increase the effectiveness of our Southern California monitoring efforts by collecting similar data at multiple sites across a large temporal scale, providing a regionally comprehensive assessment of small cetacean populations inhabiting the area. While the current small boat effort in Southern California incorporates data collection from all cetacean species encountered, bottlenose and Risso's dolphins were selected as initial focal species due to their accessibility, existing baseline data and varying life history patterns. Small vessel surveys were conducted at San Clemente and Catalina Island from 4-11 January 2011, 1-7 May 2011, and 21–25 July 2011. In addition, nineteen surveys were conducted along the San Diego coastline and offshore waters during this same time period. Monitoring results are shown in **Table S-7** with specific study accomplishments for this year provided **Appendix D**.

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9 SCORE is an older acronym for Southern California Offshore Range, and is the equivalent of the newer designation for the Southern California Range Complex.

10 Cacadia report includes 15 June, 2010 through 24 June 2011 field efforts (**Appendix D**). Only effort from 2 August 2010 through 24 June 2011 is summarized in this report.

Scripps small boat surveys accomplishments in parallel with Year Three monitoring in the Southern California Range Complex include:

- 111 hours of visual survey effort over 795 nm
- 118 sightings of 6,150 marine mammals, and 8,753 digital photographs taken
- Continuation of photoID catalogs for offshore stock of bottlenose dolphins
- Continuation of photoID catalogs for Risso's dolphins

Table S-7. Cumulative total of Scripps Institute of Oceanography small boat surveys within the Southern California Range Complex from August 2010 to August 2011.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Coastal Bottlenose Dolphin	79	729	7592	15	2
Offshore Bottlenose Dolphin	2	18	59	-	-
Risso's Dolphin	1	26	307	-	3
Pacific White-Sided Dolphin	4	29	79	-	1
Short-Beaked Common Dolphin	5	3634	14	-	-
Long-Beaked Common Dolphin	7	1615	43	-	-
Common Dolphin, Species unknown	4	69	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	6	7	34	-	
Blue Whale	10	23	625	-	-
Total	**118**	**6,150**	**8,753**	**15**	**6**

Scripps Institute of Oceanography marine mammal surveys during California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys

The Navy's Research monitoring program funds marine mammal surveys during regularly occurring California Cooperative Oceanic Fisheries Investigation (CalCOFI) field cruises. Scripps Institute of Oceanography, Marine Physical Laboratory participates as marine mammal observers during these Southern California CalCOFI cruises.

More information on the 61-year history of the CalCOFI program is available online at: http://www.calcofi.net/

The CalCOFI marine mammal efforts represents some of the few winter vessel surveys within Southern California, consistent sampling of the same survey track lines, and coverage of a significant amount of offshore area. Specific accomplishments for marine mammal surveys during CalCOFI cruises from 02 August 2010 to 01 August 2011 include:

- 455 hours of survey effort covering 3,183 nm
- 268 sightings of 13,399 marine mammals
- 2,600 digital photographs of marine mammals taken
- 872 hours of passive acoustic recording of marine mammal vocalizations
- **Appendix D** has a more complete discussion of CalCOFI results

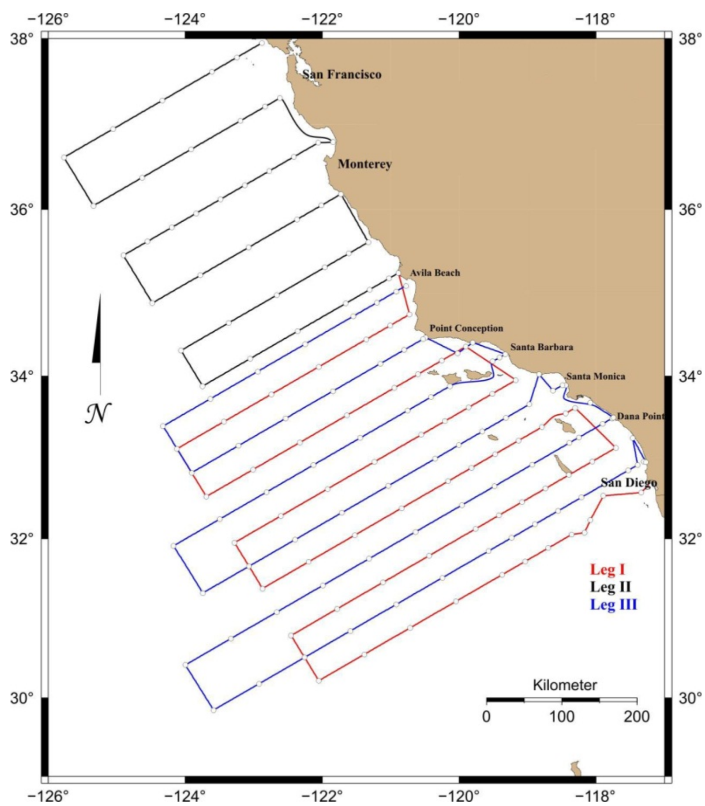

Figure S-7. CalCOFI station positions for standard transect (blue), trawling transect (red), and northern transect (black). Image courtesy of CalCOFI program.

Distribution and Demographics of Marine Mammals in SOCAL through Photo-Identification, Genetics, and Satellite Telemetry:

A summary of surveys conducted 15 June 2010 – 24 June 2011

Cascadia Research participated in the fifth and sixth year of collaborative marine mammal surveys centered on the Southern California Offshore Range (SCORE) [i.e. the Southern California Range Complex]. The primary mission of these surveys since their inception has been to provide visual verification of passive acoustic detections on the Navy instrumented underwater passive acoustic monitoring range and array using the Navy's Marine Mammal Monitoring (M3R) system (Moretti et al. 2006)[11]. Over time, these surveys have evolved to include focal studies of several species of interest to the Navy, including beaked whales and ESA listed baleen whales, via photo-identification, tissue sampling, and the deployment of medium duration satellite tags.

This work has produced some of the first U.S. West Coast tagging of Cuvier's beaked whales (see **Appendix D**). Processing and analysis of photo-identification data for all species is underway.

Cascadia survey, photoID, and tagging accomplishments in parallel with Year Three monitoring in the Southern California Range Complex include:

- 154 hours of visual survey effort over >1,664 nm
- 99 sightings of 2,287 marine mammals
- 16 biopsies taken
- 14 medium duration Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) satellite tracking tags deployed
- Five fin whales, one sei/fin, one Baird's beaked whale, two Risso's dolphin, one killer whale, one sperm whale and three Cuvier's beaked whale

Tagging Highlights

Figure S-8 shows the long-term movement of five tagged Cuvier's beaked whale from the June 2010 and January 2011 surveys. Three of the five individuals showed movements away from the San Nicolas Basin, two of the three returned. This represents one of the first indications that Southern California beaked whales may engage in non-local, out of area movement, although the biological significance for this activity is not understood, nor is it known at this time if this is indicative for all beaked whales. **Figure S-9** Shows movement of fin whales tagged during the contract period in the San Nicholas Basin. While there was some limited use of nearshore waters among the Channel Islands, including within the three-mile vessel exclusion area around SWAT 1 and 2 on the north end of San Clemente Island, individuals largely spent time in deep water, and farther offshore. **Figure S-10** showing movements of three tagged Risso's Dolphins, June 2010 thru May 2011.

11 Moretti D., Morissey R., DiMarzio N., and Ward J. 2006. Verified passive acoustic detection of beaked whales (*Mesoplodon densirostris*) using bottom-mounted hydrophones in the tongue of the ocean, Bahamas. Applied Acoustics 67:1091–1105.

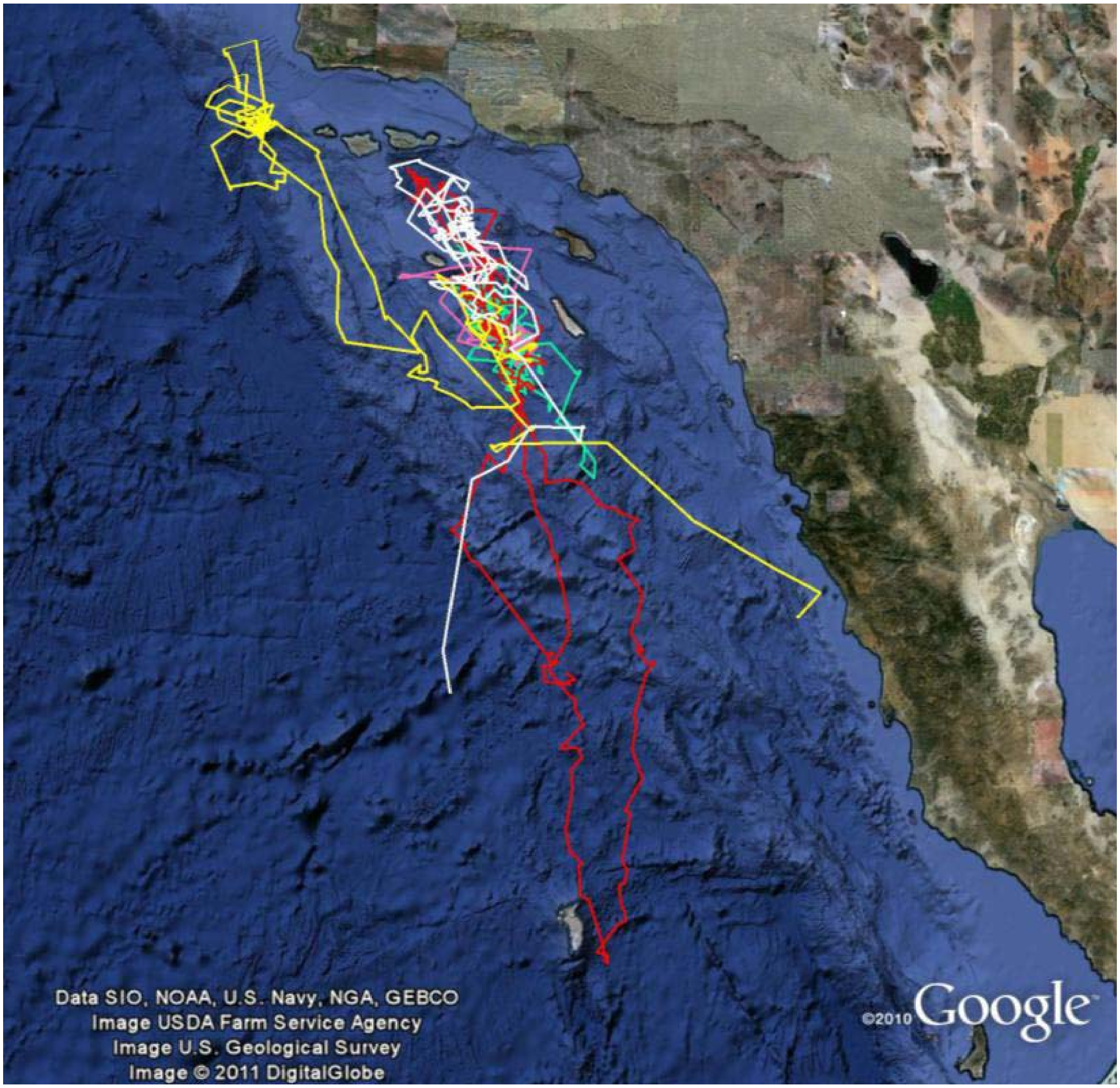

Figure S-8. Movements of five tagged Cuvier's beaked whales.

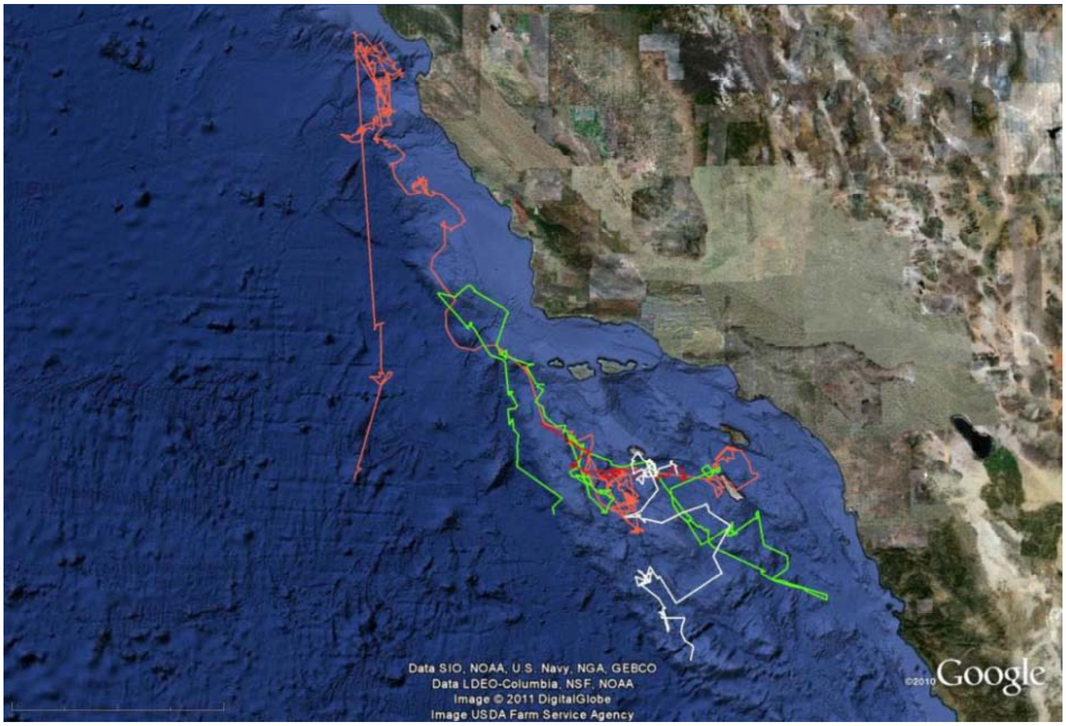

Figure S-9. Movement of fin whales tagged during the contract period in the San Nicholas Basin.

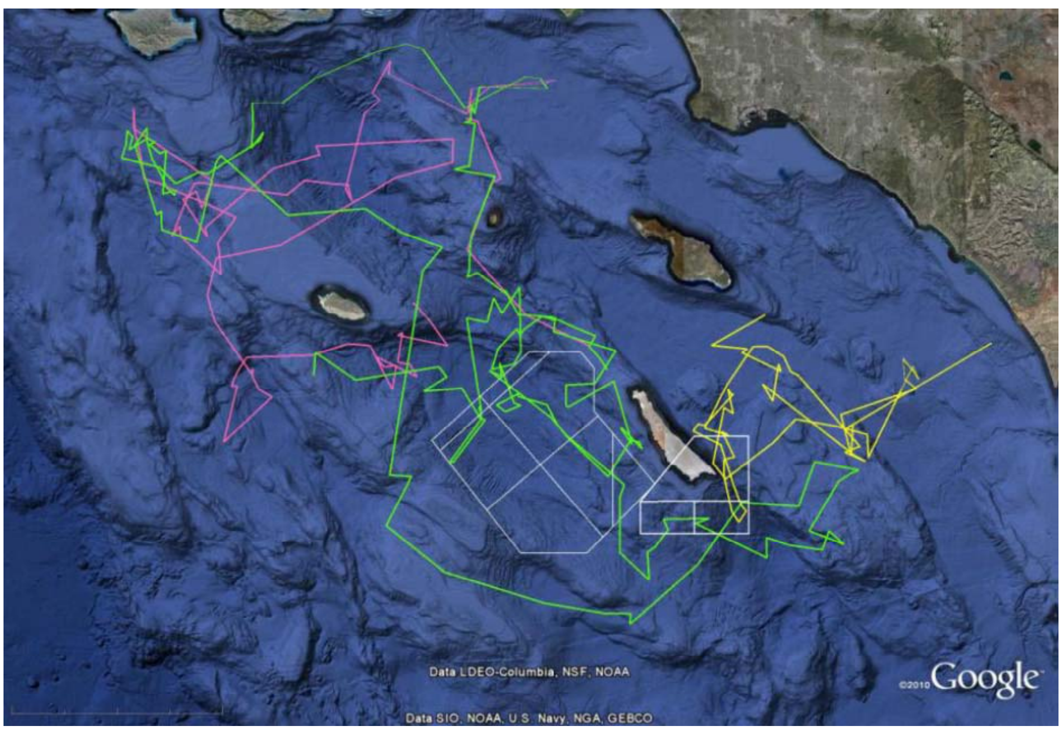

Figure S-10. Map showing movements of three tagged Risso's Dolphins, June 2010 thru May 2011. Note the SOAR and SHOBA ranges outlined in white.

SOCAL-10

SOCAL-10 was a scientific research project conducted in Aug-Sept 2010 in important biological areas near southern California. It extended previous studies in the Bahamas (2007-08) and Mediterranean Sea (2009) of whether and how marine mammals change their behavior when they are exposed to different sounds. Each of these studies has integrated behavioral response studies to controlled sound exposures with ongoing research on diving, foraging, and social behavior. The overall objective was to provide a better basic understanding of marine mammal behavior, while providing direct scientific information for the Navy and regulatory agencies to estimate risk and minimize the effect of human sounds, particularly military sonar. SOCAL-10 was the first in a five-year dedicated effort to study a variety of marine mammal species in areas around the southern California coast and Channel Islands.

SOCAL-10 involved an interdisciplinary collaboration of experts in marine mammal biology, behavior, and communication, as well as underwater acousticians and specialized field researchers. During a preliminary scouting phase and two research legs on different research vessels, SOCAL-10 observed, photographed, and/or tracked in detail, individuals of 21 different marine mammal species. Sixty-three tags (of six different varieties) were successfully secured on 44 individual animals of nine different marine mammal species, including several which had never been studied using tag technologies previously. Scientists also conducted 28 controlled sound exposure experiments; in these experiments, animals were monitored with suction cup acoustic sensors, remote listening devices and specialized observers with high-powered binoculars. Sounds were then played to the animals under specific protocols and protective measures (to ensure animals were not harmed) and changes in behavior were measured.

Preliminary results based primarily on clearly observable behavior in the field and from initial data assessment indicate variable responses, depending on species, type of sound, and behavioral state during the experiments. Some observations in certain conditions suggest avoidance responses, while in other cases subjects seemed to not respond, at least overtly. Additional analysis and interpretation is underway of the nearly 400 hours of tag data from the project, as well as thousands of marine mammal observations, photographs, tissue samples, and acoustic measurements.

http://www.sea-inc.net/SOCAL10/

Southern California marine mammal tagging efforts under the SOCAL-10 project in September 2010. Photos courtesy of SOCAL-10.

CONCLUSIONS FOR SOUTHERN CALIFORNIA RANGE COMPLEX YEAR THREE MONITORING

The Navy achieved all of its planned annual monitoring objectives in Year Three from 02 August 2010 to 01 August 2011. Most of the data collected will continue to be pooled with previous year's effort for continued scientific analysis over the full five-year Southern California Range Complex authorization.

Significant contributions were made in Year Three to learn more about baseline marine mammal occurrence, movement, and behavior within the Southern California Range Complex. To this end, over 21,196 nm of coastal and offshore waters within the Southern California were visually surveyed. These surveys occurred both during and without Navy major training events. Refinement on techniques and procedures continued for satellite tagging of ESA-listed baleen whales, Cuvier's beaked whales, and other species of interest. Passive acoustic monitoring provided the first long-term analysis of marine mammal vocalizations as an indicator of presence or absence across both warm and cold seasons. In the spirit of collaboration and information sharing within the marine science community, visual survey data from the Navy's Year One (2008-2009), Year Two (2009-2010) and Year Three (2010-2011) efforts will be made available online for download by the spring or early summer of 2012.

Finally, **Appendix A** contains the Navy's proposed Year Four Southern California Range Complex Monitoring Plan for the period 02 August 2011 to 01 August 2012. Most of the same techniques used as measures of accomplishments for Year Three will also apply in Year Four.

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APPENDIX A. Southern California Range Complex Year Three Monitoring Plan and Adaptive Management Discussion for the period 02 August 2011 to 01 August 2012

Prepared for
National Marine Fisheries Service
Office of Protected Resources

Prepared by
Department of the Navy
U.S. Pacific Fleet

Southern California Range Complex

Year Four Monitoring Plan

02 August 2011 to 01 August 2012

01 October 2011

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Proposed YEAR Four (2012) Monitoring

For 2012 through 2014, the U.S. Navy proposes to keep the same level of monitoring effort in the Southern California Range Complex as was committed and accomplished in 2011. Table 1 highlights these goals.

In support of the Joint Subcommittee on Ocean Science and Technology recommendations, Southern California workshop recommendations, and Ocean Policy direction (Southall et al. 2009, OSTP 2009, CEQ 2010, EO 2010, Foley et al. 2010), the U.S. Navy is committed to structuring the Southern California Range Complex monitoring to address both NMFS regulatory required monitoring under the Southern California Range Complex Letter of Authorization while at the same time making significant contributions to the greater body of marine mammal science. The U.S. Navy assembled a Scientific Advisory Group comprised of leading marine mammal scientists as well as convened monitoring meetings with NMFS, researchers, and non-governmental organizations in October 2010 and June 2011 with the interest of soliciting input on future range complex monitoring objectives and methods. Recommendations generated during those meetings are currently under review by the U.S. Navy and NMFS and will be used to revise and improve the U.S. Navy's monitoring program from 2012 to 2014. Those recommendations will not be available for incorporation into this report therefore changes will be made under separate submission.

Table 1. U.S. Navy's proposed Year Four monitoring goals for the Southern California Range Complex.

<table>
<tr><th>Monitoring Technique</th><th colspan="2">Implementation</th></tr>
<tr><td>Visual Surveys</td><td>Portions of major training events, or unit level training events using sonar; or offshore or inshore detonation events
(100-150 combined hours annually; 200-300 combined hours over 2-years)</td><td rowspan="6">Adaptive Management Review for 2013</td></tr>
<tr><td>Marine Mammal Observers</td><td>Opportunistic; major training events, unit level training events, or offshore or inshore detonation events as available
(58-100 total hours annually; 108-200 total hours over 2-years)</td></tr>
<tr><td>Passive Acoustics Monitoring</td><td>Continue data collection and analysis from passive acoustic recording device(s)</td></tr>
<tr><td>Southern California Range Complex Exercise Summary From Navy Lookout Reports</td><td>Continue to collect/analyze marine mammal sightings from Navy lookouts during major training events and present results (data from Southern California Range Complex Exercise Report)</td></tr>
<tr><td>Marine Mammal Tagging (MMT)</td><td>Present results from ongoing, other Navy funded (OPNAV N45) marine mammal research in Southern California</td></tr>
<tr><td>Visual surveys, M3R, PhotoID</td><td>Present results from ongoing, other Navy funded (OPNAV N45) marine mammal research in Southern California</td></tr>
<tr><td colspan="3">TOTAL U.S. Navy 2012 Goal:
• Conduct additional analysis of field data collected from Years 1-4
• 100 to 150 hours visual survey field efforts
• 58-100 hours Marine Mammal Observers
• PAM: continue data collection/analysis from passive acoustic recording devices
• Present results as available from other U.S. Navy funded research projects such as visual surveys, passive acoustic monitoring, tagging, and photoID</td></tr>
</table>

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APPENDIX B. Southern California Aerial Survey Reports and Manuscripts

Sub-sections

27 July – 3 August 2010 (18.1 hours) and 24 – 28 September 2010 (28.6 hours)

23 -28 September 2010 (19.2 hours), 14 – 19 February 2011 (18 hours), 29 March – 3 April 2011 (9.5 hours), 12 – 20 April 2011 (46.1 hours), and 9 – 14 May 2011 (27 hours)

Navy-Funded Manuscripts contract issued to SES

Bryde's Whale (*Balaenoptera brydei/edeni*) Sightings in the Southern California Bight

Density and Abundance of Marine Mammals around San Clemente Island, San Diego County, California, in 2008-2010

Behavior and Group Characteristics of Marine Mammals in the Southern California Bight 2008-2010

Marine Mammal and Sea Turtle Monitoring Video during Navy Training Events

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Aerial Survey Marine Mammal Monitoring off Southern California in Conjunction with US Navy Major Training Events (MTE)

Mari A. Smultea[1], Cathy Bacon[2] and Jenelle S. Black[3]

Citation for this report is as follows:

Smultea, M.A., C. Bacon and J.S.D. Black. 2011. Aerial Survey Marine Mammal Monitoring off Southern California in Conjunction with US Navy Major Training Events (MTE), July 27- August 3 and September 23-28, 2010 – Final Report, June 2011. Prepared for Commander, Pacific Fleet, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI, 96860 3134, under Contract No. N00244-10-C-0021 issued to University of California, San Diego, 7835 Trade St., San Diego, CA 92121. Submitted by Smultea Environmental Sciences (SES), Issaquah, WA, 98027, www.smultea.com, under Purchase Order No. 10309963.

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SECTION 1 INTRODUCTION

Per the Scope of Work (SOW), this report provides a combined summary of aerial surveys conducted in July and September 2010 in support of the U.S. Navy's (Navy) Marine Mammal Monitoring Plan (M3P) in the Southern California Range Complex (**Figure 1**) (SOCAL) (DoN 2009). These were the seventh and eighth such aerial surveys in SOCAL conducted by SES or SES/Marine Mammal Research Consultants (MMRC). Monitoring occurred before, during, after and in conjunction with several Navy Major Training Events (MTEs) involving mid-frequency-active sonar (MFAS).

Protocol was the same as that implemented for aerial surveys in SOCAL in November 2009 (Smultea and Lomac-MacNair 2010) and May 2010 (Smultea et al. 2010). The survey purpose was to obtain baseline data and monitor for potential effects of MTEs on marine mammals (see Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010). However, for the first time during the July 2010 survey, a helicopter (Bell 206) was used for part of the survey to assess the feasibility and utility of this platform to address survey goals, particularly collecting behavioral data using focal follow techniques by circling sightings for extended periods and obtaining video (see Methods below).

SECTION 2 METHODS

Methods followed those used in previous SOCAL aerial surveys as described in Smultea et al. (2009a,b; 2010a,b). Differences from previous methods are identified below.

Two aircraft were used for the July survey: (1) a fixed-wing, twin-engine Partenavia P-68 OBS Observer with a glass nose (the same one used on our previous SOCAL surveys), and (2) a Bell 206 helicopter (front cover)(both owned and operated by Aspen Helicopters, Oxnard, California). The helicopter was used evaluate its utility for conducting focal observations given its advantages of larger and multiple-opening windows and the ability to circle at a slower speed around focal groups. During the September survey, the Partenavia Observer was the only aircraft used.

The only opening window in the Partenavia was a small (approximately 4-inch diameter) flip-up circular window in the right front seat where the recorder/videographer/photographer sat. Two observers sat in the two middle seats of the plane and looked through bubble windows (that did not open). In the helicopter, 12 by 12 inch sliding windows opened in the rear two seats where two observers sat, and an approximately 6 by 12 inch sliding window opened in the front left seat where the recorder/photographer sat. In the helicopter, the pilot sat in the right front seat while the survey recorder/photographer sat in the left rear seat.

A Sony HD HDR-XR550 12.0 megapixels video camera with a 10x zoom lens, internal image stabilization, and a 1.4 power converter lens were used to video focal follow groups. The video camera was mounted on a 30-cm telescoping chest pod to improve stabilization. (A Canon HD video camera was used during the five aerial surveys prior to May 2010).

Prior to the September 2010 survey, SES communicated with the Navy NTR and Dr. Brandon Southall of Southall Environmental Associates to identify ways in which the aircraft crew could assist the SOCAL Behavioral Response Study (BRS). Plans were made to contact the BRS group via email or cell phone each evening to learn the proposed location of the BRS survey vessels the following day, and to identify how efforts could be coordinated. Each morning, the survey aircraft would contact the BRS vessel when within range (~20 km or 10 nm) of the pre-communicated study area and identify how/if the aircraft crew could aid the BRS. The latter generally consisted of identifying and communicating the locations of cetaceans within their study area, and/or assisting them in relocating sightings.

SECTION 3 RESULTS

This section follows the format of the Nov 2009 and May 2010 SOCAL aerial survey monitoring reports (Smultea et al. 2010a,b). The exception is that sighting encounter rates for the May, July and September SOCAL aerial surveys are included herein, per the SOWs. Results are summarized in **Tables 1 - 10**, **Figures 2-4**, and **Appendices A - E**. Unlike previous reports, **Tables 1 and 2** indicate aerial survey days when MTES-associated MFAS were operating in SOCAL. This activity occurred on five of the seven July 2010 survey days, including the first survey date of July 27. During the September survey, MTES-associated MFAS were operating on only two days.

Effort

27 July – 3 August 2010

A total of 18.1 hr of flight time and 3125 km (1688 nm) of effort occurred during the July 2010 SOCAL aerial survey between aircraft "wheels up" off the ground to "wheels down" when the plane landed (**Tables 1 and 3**). Surveys were flown on seven days from July 27 to August 3; no survey occurred on August 31 due to aircraft mechanical repair needs. Most (74% of 14.3 hr) effort occurred with the fixed-wing aircraft on four days (July 29-31, August 2-3). The remaining 26% (5.1 hr) occurred from the helicopter on the first two survey days (July 27-28). Overall, most (50%) of the total 3125 km of effort involved circling sightings for focal follows and/or species identification. This was followed by transit (21%) and systematic line-transect (19%) (**Table 4**). Beaufort sea state rating (Bf) ranged from 2-6 during the July survey. Bf 3 predominated (16%) followed by Bf 2 (12%) (**Figure 2**). July and August 2010 had an unusually high number of days with a heavy low marine fog layer over the SOCAL. During the survey period, heavy fog typically persisted through the morning until early afternoon and returned in early evening. Even in the middle of the day, when the marine layer sometimes lifted, the ceiling was low (approximately 1000-2000 ft).

Effort occurred in SOAR west of San Clemente Island only on July 30 and was limited to the two northernmost survey lines due to low clouds and to avoid airspace conflicts with Navy activities as directed by Navy personnel (**Tables 1 and 4**). Remaining effort occurred in NAOPA. Helicopter effort occurred in coastal areas usually within ~15 km of the coastline and ~60 km from San Diego. Helicopter effort was focused there because the range of this aircraft with four personnel onboard was about 2.7 hr, and the hourly cost to operate it was about 2.5 times higher than the cost of the Partenavia fixed-wing plane.

24 – 28 September 2010

A total of 28.6 hr of flight time and 5314 km (2871 nm) of effort occurred during the September 2010 SOCAL aerial survey ("wheels up" to "wheels down") (**Tables 2 and 4**). Surveys were flown on six days from September 23 - 28. Overall, most (44%) of the total 5314 km of effort involved transiting between the airport and survey grid locations. This was followed by systematic line-transect (27%) and circling effort (26%) (**Table 4**). Beaufort sea state ranged from 1-5 during the September survey. Bf 2 predominated (53%) followed by Bf 3 (31%) (**Figure 3**).

Effort occurred in SOAR on four days with the remaining two days occurring in NAOPA (September 26 and 27). Effort was coordinated with the BRS study on 26-28 September and included conducting mini-transects on the NW corner of SOAR to help the BRS locate sightings (see **Table 2** for details).

Sightings

July 2010

A total of 86 sightings of ~11,090 individual marine mammals were observed in July 2010 (**Table 5**). Of the total 86 sightings, 78% were identified to species (n = 27) or genus (n = 40 common dolphin sp.). Not all sightings were identified to species because there was not always time to fly off course to identify and circle sightings. Rather, the priorities were to conduct focal follows on priority species and/or to reach and conduct a full survey in SOAR which required a full tank of fuel to complete (i.e., there was not enough fuel to circle species seen en route to or from the airport and SOAR).

Seven different marine mammal species were identified. Sightings included two baleen whale species (blue and fin whales), four dolphin species (bottlenose, short- and long-beaked common, Risso's), and one pinniped species (California sea lion). Overall, the common dolphin was the most frequently identified species genus (47% or 40 of 86 total groups) followed by the blue whale (21% or 18 groups). In terms of number of individuals seen, the common dolphin was also the most abundant (n = ~9354 or 84% of the total ~11,090 individuals seen).

September 2010

A total of 252 sightings of ~37, 874 individual marine mammals were observed in September 2010 (**Table 6**). Of the total 252 sightings, 35% were identified to species (n = 89) or genus (n = 124 common dolphin sp.). Not all sightings were identified to species as described above.

Nine different marine mammal species were identified. Sightings included three baleen whale species (Bryde's, minke and possibly sei whales), three dolphin species (long-beaked common, bottlenose and Risso's), and two pinniped species (California sea lion and northern elephant seal). Overall, the common dolphin was the most frequently identified species genus (49% or 124 of 252 total groups) followed by the California sea lion (28% or 71 groups). In terms of number of individuals seen, the common dolphin was also the most abundant (n = ~34,127 or 90% of the total ~37, 874 individuals seen).

SIGHTING ENCOUNTER RATES

Sighting encounter rates are tabulated in several tables, due to their large sizes. **Tables B-1 and B-2** compare sighting rates based on combined systematic, random and transit effort (i.e., point-to-point linear effort) during the November 2009 and May and July 2010 SOCAL aerial surveys. (See Smultea and Lomac-MacNair 2010 for other results of the November 2009 SOCAL aerial survey.) Sighting rates based on the number of *groups* sighted per km, per nm and per hour (i.e., number of sightings) are shown separately in **Table B-1**; the number of *individuals* sighted per unit effort is displayed in **Table B-2**. Sighting rates by survey effort type are provided in **Tables B-3 and B-4**, respectively. (See **Table 3** for definitions and total km and nm of effort types.) Sighting rates were similar across systematic effort for the three survey months, but differed for transit and random effort.

The overall numbers of sightings per unit effort were similar across November, May and July. However, the sighting rate based on number of individuals was about three times higher in November than May and twice as high in July as May. September was roughly 3 times higher than July and more than 7 times higher than May.

In July, overall sighting rates were about two to four times higher during transit vs. random and systematic effort. This was believed to have been an artifact of flying over a known area of marine mammal concentration near San Diego and La Jolla every day en route to and from Montgomery Airport. In contrast, systematic and random effort included large areas where we have found marine mammal densities to be relatively low.

In September, overall marine mammal sighting rates were about two to three times higher during transit vs. random and systematic effort. Systematic effort for September 2010 was much higher than those of the three other survey months. During random effort, individual sighting rates were five to seven times lower during May vs. November, July and September, most evidently for dolphins. For transit effort, individual sighting rates were at least five times higher during July and September vs. May and November. There was less difference across survey months for group sighting rates. See Smultea et al. (2010) for further discussion of sighting rates during SCI circumnavigation effort, this effort type did not occur in September 2010.

Distribution

July Effort Distribution

In July 2010, three (July 27-29) of the seven survey days were dedicated to opportunistic focal observations and did not entail systematic search effort (see **Table 3**). The remaining four days were line-transect survey effort: three days in NAOPA and one day in SOAR. Although access to SOAR was permitted by the Navy on two days from 10:00-15:00, fog precluded this effort except for the afternoon of July 30th on the two northernmost lines of SOAR. NAOPA and SOAR transect lines were the same as those followed in November 2009 and May 2010 (Smultea and Lomac-MacNair 2010, Smultea et al. 2010).

July Sighting Distribution

Relatively high numbers of blue whales (n = 18 sightings) were seen during July 2010, similar to the July 2009 survey (see Smultea et al. 2009b). On five of seven survey days 3-6 blue whales were consistently seen in the same small area ~5 km (~2 nm) west of La Jolla near a large buoy (**Figures 2 and 4**, **Appendix A**). This apparent concentration may be partially biased because we flew over this area every day en route to and from Montgomery Airport. However, 92% of all blue whale groups were seen within 15 km (8 nm) of the mainland coast, despite considerable effort further offshore, indicating that blue whales prefer coastal SOCAL waters. All four fin whale sightings were within 10 km (5 nm) of the mainland near San Diego. Blue and fin whales were also observed in this coastal area during previous surveys (see Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010, Smultea et al. 2010). The location coincides with the drop-off of the coastal underwater shelf topography.

Dolphin distribution was concentrated in coastal areas: 80% of 40 common dolphins, 86% of 19 unidentified dolphin, and 100% of three common bottlenose dolphin groups were within 20 km (10 nm) of the mainland (**Figure 4**) (Notably, most of the unidentified dolphins are believed to have been common dolphins based on relatively large group sizes and frequent surface-active behavior we have found to be characteristic of this species per other surveys). However, this observed distribution was partially biased by concentrated effort near San Diego while en route to and from the airport and during opportunistic focal follows on blue and fin whales. Only 11 (17%) of the total 63 dolphin groups were seen over 20 km from shore despite considerable line-transect effort farther offshore. Although only one Risso's dolphin group was seen (just north of SCI), it was the farthest offshore sighting. Similarly, an apparent inshore-common-dolphin and offshore-Risso's-dolphin distributional segregation was seen during May 2010 (see Smultea et al. 2010). In general, similar to May 2010 (Smultea et al. 2010), common and unidentified dolphins were fairly evenly distributed along the mainland coastline and did not appear to be strongly associated with any bathymetric features except the continental shelf. Further examination of photos may allow differentiation of short- and long-beaked dolphins and potential associated differences in distribution. No dolphins were seen along the two northernmost survey lines in SOAR.

Only one pinniped sighting, a California sea lion, was seen during the July 2010 survey and occurred close to the San Diego coast (**Figure 3**). This was the fewest pinniped sightings made during any of the total seven SOCAL aerial surveys we have done (see Smultea et al. 2009a, b, Smultea and Lomac-MacNair 2010, Smultea et al. 2010). This is attributed to very little effort near SCI where they are known to concentrate, and to the late summer season when their numbers in SOCAL are reduced as many individuals have migrated farther north to feed (Jefferson et al. 2008, DoN 2009).

September Effort Distribution

In September 2010, four (September 24, 26-28) of the six survey days were dedicated to opportunistic focal observations and did not entail systematic search effort. The remaining two days were line-transect survey effort: one day in NAOPA and one day in SOAR. NAOPA and SOAR transect lines were the same as those followed in November 2009, May 2010 and July 2010 (Smultea and Lomac-MacNair 2010, Smultea et al. 2010).

September Sighting Distribution

Relatively few whales were seen during September 2010 (n = 6 sightings), similar to the May 2010 survey. The two Cuvier's beaked whales, one Bryde's whale, and three minke whales were seen in the far northwestern corner of SOAR (**See Figure 3 in Appendix B in aerial report 01 August 2010 to 31 July 2011**); in comparison, during October 2008, November 2008 and May 2010, whales (mostly baleen whales) were seen relatively frequently in this small area, but appeared to concentrate between SW SCI and Tanner Bank to the west (see Smultea et al. 2009a, Smultea et al. 2010). In November 2008, another small concentration of whale sightings occurred ~20 km NW of San Diego directly W of Montgomery Field where the survey aircraft crossed nearly daily during transits to survey areas. This area encompassed the La Jolla and Scripps canyons; in contrast, only one whale was seen here in October 2008 and three whales in September 2010 (Smultea et al. 2009a). Blue whales were not seen during the September survey.

Dolphin distribution was not concentrated in coastal areas like it was during the July 2010 survey. Common dolphins were concentrated in coastal areas but also seen on transect lines heading out to SOAR (**See Figure 5 in Appendix B in aerial report 01 August 2010 to 31 July 2011**). Forty-two percent of 125 common dolphins, 86% of 32 unidentified dolphin, and 50% of 4 common bottlenose dolphin groups were within 20 km (10 nm) of the mainland (**See Figure 5 in Appendix B in aerial report 01 August 2010 to 31 July 2011**). Only 11 (17%) of the total 167 dolphin groups were seen over 20 km from shore despite considerable line-transect effort farther offshore. Dolphin sightings during September were more evenly distributed throughout the SOCAL range compared to July. Only one group of Risso's dolphin was seen in July (n =9) compared to the six groups seen in September (n = 74) and these sightings mainly occurred within the SOAR range.

High numbers of California sea lions (n = 71 sightings) were seen during the September 2010 survey and occurred west of San Clemente Island within the SOAR range (**See Figure 7 in Appendix B in aerial report 01 August 2010 to 31 July 2011**). This was the highest number of pinniped sightings made during any of the eight SOCAL aerial surveys we have done (see Smultea et al. 2009a, b, Smultea and Lomac-MacNair 2010, Smultea et al. 2010)

General Behavior

Common dolphins and blue whales had sample sizes considered large enough (n = 40 and 18, respectively) to warrant summarizing initially observed behavior state, heading, and estimated mean dispersal distance between individuals. Common dolphins were most frequently observed in surface-active behavior states and travel (6, top panel). This behavior is consistent with that observed during our past six aerial surveys (Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010, Smultea et al. 2010). Travel speed was predominantly medium to fast. Common dolphins were most frequently observed headed southwest to west; this was the same predominant heading observed for common dolphins during June and July 2009 (Smultea et al. 2009). Inter-individual spacing (i.e., dispersal) for common dolphins was nearly always 1-3 body lengths (97% of 38 groups), consistent with our past six aerial surveys.

Focal Follows

Focal follow effort was emphasized more during the July and September 2010 aerial surveys compared to previous aerial surveys which more equally distributed line-transect and focal-follow effort. This shift in study focus resulted from a shift in the Navy's Statement of Work to concentrate on collecting baseline behavioral data relative to the need per the M3P to assess potential effects of MFAS exposure on marine mammals and sea turtles (DoN 2009). The shift was also related to increased interest by NMFS in the latter topic.

As during previous surveys since summer 2009, the goal was to conduct focal follows with video for at least 10 min with Risso's dolphins and up to 60 min with ESA-listed whales such as blue and fin whales. Shorter focal follows involving circling of animals to photo-verify species occurred for 5-9 min.

A total of 19 focal follows at least 5 min long totaling 553 minutes (9 hr 13 min) occurred during the July 2010 survey Five (26%) of the 19 focals occurred from the helicopter and totaled 194 min (3 hr 14 min). The remaining 74% (n = 14) occurred from the airplane and totaled 359 minutes (5 hr 59 min). Most (68%) of the total 19 focals were at least 10 min long.

During the July 2010 survey, all nine of the blue whale focals were over 10 min long and four were over 1 hour long. Video was taken on eight of the nine blue whale focal groups. In addition to common dolphin sp., focal follows occurred with Risso's dolphins, two minke whale groups, sei whales, large groups of California sea lions, and two unidentified baleen whales. Only eight of 17 common dolphin focals lasted over 10 min, six of which included video; the remaining seven common dolphin focals involved only circling of the group to verify species by taking photos. However, further preliminary detail on observed behaviors is provided in the Appendices and in the description below.

During the September 2010 survey, a total of 16 focal follows at least 5 min long totaling 274 minutes (4 hr 34 min) was conducted. Most (56%) of the total 16 focals were at least 10 min long. Over half (56% or 9) of the 17 focals were common dolphin sp. Focal sessions occurred more frequently with common dolphins than during previous surveys because they engaged in synchronized swimming and foraging behaviors in groups of twos and threes, and this behavior had not previously been seen; unusually high numbers of bait balls were also seen during the surveys.

Unusual Observations

Summarized below are unusual encounters and associated made during the July and September surveys. These encounters are included because they are considered rare based on previous efforts, and/or there are few if any available data or literature on such observations. Notably, the prolonged overhead view from the helicopter circling overhead outside the predicted Snell's Cone sound radius of the aircraft allowed a "bird's eye view" of the animals both above and below the surface without affecting their behavior in a noticeable manner. In particular, videotaping from the helicopter allowed us to keep the animals within view for longer periods than from the airplane given that the helicopter can circle safely at slower speeds. The animals were circled at a radial distance of approximately 1 km and an altitude of 1200-1500 ft.

Photographs and Video

Lists of photographs and video are presented **in Appendices D and E**. Note that the video is based on start and stop times, and focal animals are not always in view and videotaped; the video was typically kept on between surfacings to record ancillary information. The count of photographs is a raw count and has not been filtered in detail to identify usefulness of photographs to identify species, calves, etc. The latter tasks are time consuming and were outside the scope of this contract.

About 2900 digital photographs and ~4.3 hours of HD video were taken during July 2010. Approximately 17% of the photos were taken from the helicopter with the remaining 83% taken from the fixed-wing Partenavia airplane. Approximately 41% of the video was made from the helicopter on two days vs. 59% from the airplane in five days.

A preliminary total of ~741 digital photographs and ~2.4 hours of HD video were taken during September 2010. The helicopter was not used during the September survey, 100% of the photos were taken from the fixed-wing Partenavia airplane.

SECTION 4 DISCUSSIONS

Comparison of Airplane vs. Helicopter Platforms

For the first time during our seven SOCAL aerial surveys, for the July 2010 survey we used a Bell 206 helicopter as a platform from which to conduct behavioral observations. We did this to ascertain the relative utility of this platform vs. the fixed-wing Partenavia we have used for previous surveys. **Table 7** summarizes our comparison.

Aerial Survey Collaboration with Other Researchers

During July, it was not logistically feasible to collaborate in real-time with other marine mammal researchers in the SOCAL range during our July survey to our knowledge, as they were not conducting field studies in the same area simultaneously. However, upon request, we provided a list of our blue whale sightings to J. Calambokidis (JC) of Cascadia Research Collective (CRC) that included the dates, times, numbers, and locations of our blue whale sightings. During our survey, JC was simultaneously conducting small-vessel surveys for blue whales in the Santa Barbara Channel area. He requested our data because he was scheduled to conduct small-vessel surveys in the SOCAL in early August and September as part of the BRS led by Dr. Brandon Southall and funded by N45 and Office of Naval Research Funds. Our sighting data have been shared with researchers from UC San Diego/Scripps Institute of Oceanography, CRC, the Navy's Marine Mammal Research Program (e.g., Dr. Dave Morretti), and other Office of Naval Research and N45-funded studies, including the BRS.

Shared data of interest that we have collected include locations and photographs of blue and fin whales and Risso's dolphins. In particular, baseline behavioral and distribution data we have collected on these and other species is of relevance to the BRS program. In fall 2010, the BRS program began conducting playback sound studies to some of species to assess potential behavioral responses. Thus, our baseline behavioral data provide a substantial source for comparison of typical behavior of these species. Few published data are available on the behavior of any of the marine mammals species inhabiting the SOCAL with the exception of coastal bottlenose dolphins (e.g., Defran et al. 1999), gray whales (e.g., Punt and Wade 2010), and more recently, a few tagged individual Cuvier's whales (e.g., Falcone et al. 2009a, b).

SECTION 5 CONCLUSIONS AND RECOMMENDATIONS

Survey Highlights

- Dr. Bernd Würsig of the Marine Mammal Research Program at Texas A&M University joined our field team in May, July and September 2010 to provide expert review and critique of our behavioral study approach and protocol, and to assist us in the field. Dr. Würsig provided a positive review of our protocol and helped us further refine our field and post-field analysis and summary techniques. He also provided the write-up and photos for the blue-fin whale focal follow as summarized above under Unusual Observations. He also was critical in providing an expert opinion on the utility of the helicopter as a platform for conducting extended focal follows with video.
- We successfully used the Bell 206 helicopter in July 2010 to conduct behavioral focal follow observations of priority cetacean species. We concluded that this platform is advantageous over the Partenavia for taking video and obtaining detailed behavioral data, while the Partenavia is better suited for conducting line-transect surveys (see **Table 7** and subsection that follows). This is because the helicopter can fly slower circles (45 -50 kts) that allows for a better, longer view, with less interruption by glare (on sunny days) within the focal circle view. Especially important is that the helicopter can circle in a manner that keeps it approximately equal distance from the focal animal(s) throughout the circle, unlike the strong oblong pattern necessitated by the circling of a fixed wing (i.e., the Partenavia's slowest safe circling speed is approximately 80 kt). The helicopter we used also has larger photo-capable windows and less cramped space than the Partenavia, facilitating inherently better photos, both still and video. The disadvantage of the helicopter we used is its reduced range (2.6 hr vs. 4.5 hr for Partenavia) and its increased expense (almost three times the hourly cost of the Partenavia).
- We concluded and recommend that the (Partenavia) fixed-wing plane is best when the primary goal is to collect line-transect data, and the (Bell 206) helicopter is better when detailed behavioral work is warranted. Given the higher cost of the latter, we recommend judicious occasional but then dedicated use of a helicopter for behavioral focal follows. Given that behavioral data is currently a primary focus of the SOCAL monitoring per Navy input, we recommend that the helicopter be used to the maximum extent practicable during these surveys. Using both platforms during one survey as we did during July 2010 is one feasible approach. Another possible approach is to use the helicopter separately for focal sessions and the Partenavia separately for line transects. Perhaps the ideal approach would be to use both simultaneously to gather both types of data on a survey. The latter approach should be attempted to assess the utility of collecting simultaneous density/abundance/distribution data from the Partenavia while at the same time collecting extended focal follows including video from the helicopter.
- As summarized in **Appendix D-1** the July 2010 aerial survey contributed the second highest number (n = 13) of focal behavioral observations at least 10 min long relative to our previous six SOCAL aerial surveys, with only the May 2010 such sample size being larger (n = 20). This again was because we had shifted our primary focus to extended focal follows.
- The July 2010 survey contributed the highest number of blue whale focal follow sessions of any of the previous six SOCAL surveys as summarized in the text. This is important in

providing critical baseline behavioral data on this ESA-listed, "Priority" species of special concern with respect to the Navy's SOCAL monitoring plan.

- The combined SOCAL aerial data from 2008-2010 represent the largest and most recent, concentrated such survey effort within the SOCAL (**Table 10**). Our surveys also are the first behavioral-focused aircraft-based studies conducted in the SOCAL, and are the first such studies conducted on numerous species (e.g., Risso's dolphin, common dolphin, blue whale, Pacific white-sided dolphin, etc.). Given the current and increasing focus by NMFS and the Navy on assessing behavioral responses of marine mammals to MFAS activities, our data fill a unique niche and currently represent considerable sample sizes that are essential to provide adequate and relevant comparative baseline data to assess such effects.
- Funding has not been available to analyze the detailed behavior of cetacean groups we have observed in the SOCAL. It is critical that these data be further analyzed to assess and evaluate their results and utility relative to the goals of the Navy's SOCAL and other marine mammal monitoring plans. It is also critical that these data will also be analyzed relative to estimated received sound levels of MFAS, as applicable, and will provide baseline non-MFAS exposure data for comparison purposes for monitoring and other studies (e.g., the BRS study—see following subsection).
- The July, September and previous six aerial surveys contribute to building recent seasonal and year-round baseline data for the SOCAL marine mammals as directed under the SOCAL M3P.
- Behavioral trends reported herein are generally consistent with the six previous aerial surveys for common, Risso's and bottlenose dolphins as well as blue and fin whales.
- Results consistently show that blue whales and Risso's dolphins tend to remain within view of the aircraft observers at or below the surface for the longest periods compared to other SOCAL marine mammal species observed. This is in part related to the light, white body coloration and scarring of Risso's dolphins that makes them relatively easy to track from the aircraft at and below the surface, even at altitudes of 1500 feet and radial distances of 1 km at which focal behavioral follows are typically conducted.
- Other recommendations to improve data collection techniques, analyses, interpretations, and applications are the same as those provided in the previous SOCAL 2008-2009 aerial survey reports (Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010).

SECTION 6 ACKNOWLEDGEMENTS

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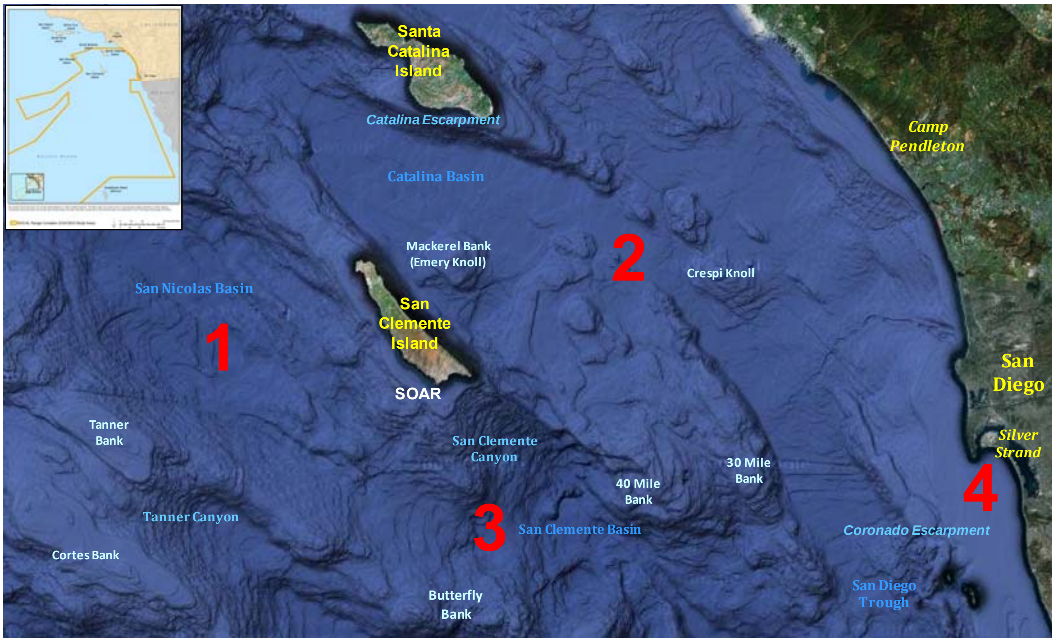

Figure 1. Location of the aerial survey monitoring area and underwater topographic features within the Navy's Southern California Range Complex (SOCAL).

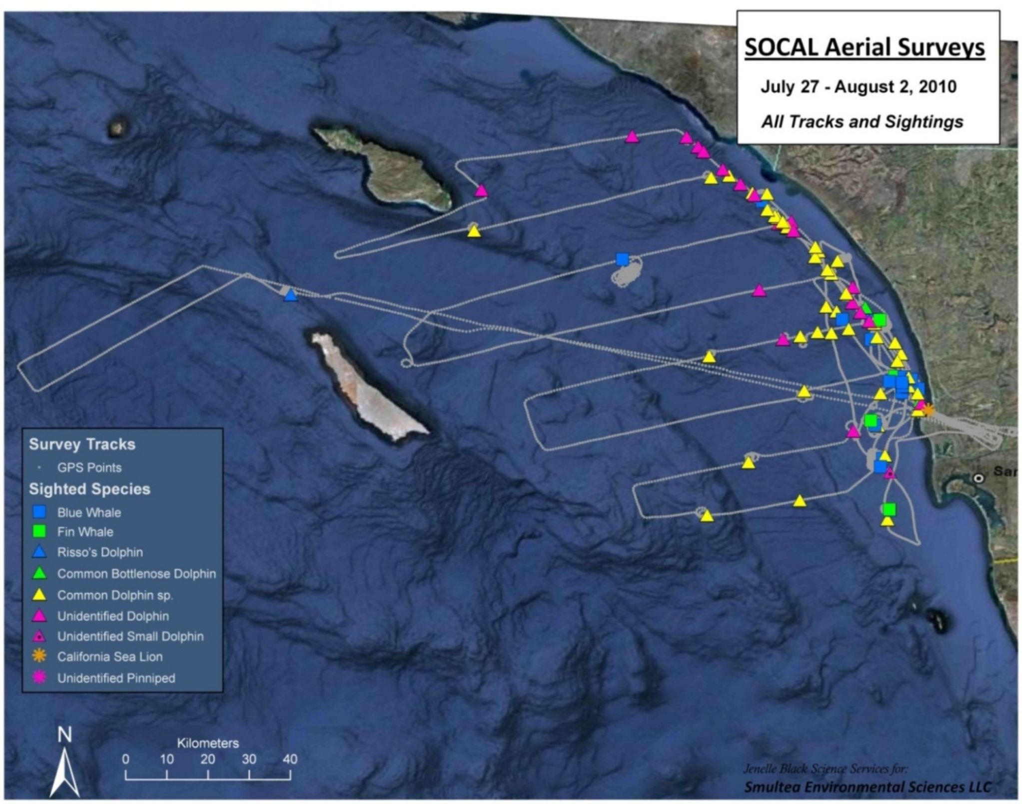

Figure 2. All track lines and sightings made during aerial monitoring surveys in SOCAL July 27 – August 3, 2010.

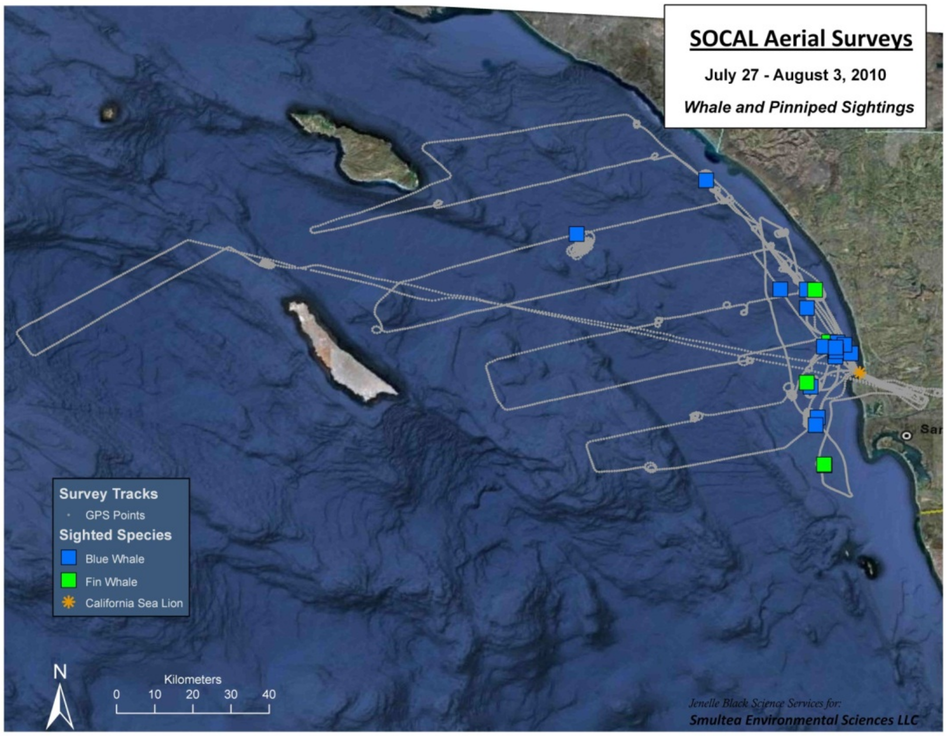

Figure 3. Whale sightings made during aerial survey monitoring in the SOCAL survey area July 27 – August 3, 2010.

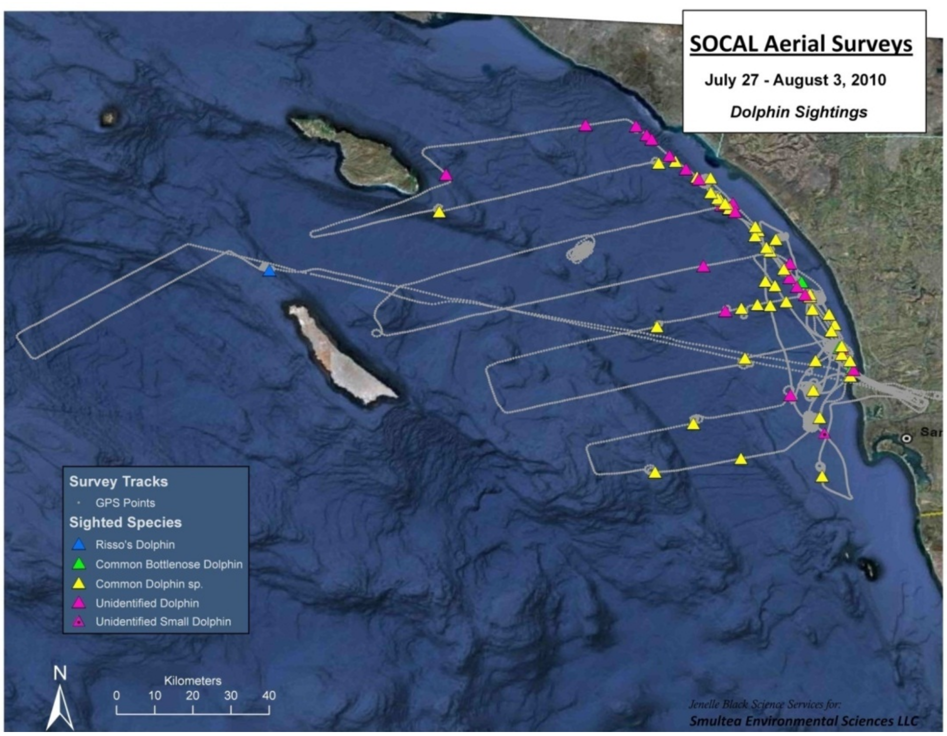

Figure 4. Dolphin sightings made during aerial survey monitoring in the SOCAL survey area July 27 – August 3, 2010.

Table 1. Aerial survey flight times, total hours (hh:mm) by date, and survey area during the July 2010 SOCAL aerial survey.

Date 2010	Flight	Platform	Location	Time Lift Off	Time Landed	Total Flight Time	Total "On Effort" Observ	MTE-assoc. MFAS?	Survey Notes
27-Jul	1	Helicopter Bell 206	Coastal NAOPA	14:01	16:35	2:34	1:20	Yes	Assessing effectiveness of helicopter as platform for focal behavioral observations with Bernd Würsig. Flew <3 nm from coast. Heavy morning fog/low clouds. Ceilings 1400-1600 ft, fog/heavy overcast. Conducted focal near San Diego on feeding blue and fin whales, observed frequent defecation.
28-Jul	1	Helicopter Bell 206	Coastal NAOPA	13:37	16:08	2:31	1:36	No	Assessing effectiveness of helicopter as platform for focal behavioral observations with Bernd Würsig. Flew <15 km from coast south to Mexican border. Heavy fog/low clouds in morning delayed departure to afternoon when ceiling was 1400-1500 ft/heavy overcast. Conducted focal on feeding blue and fin whales again in same area as yesterday.
29-Jul	1	Partenavia OBS	NAOPA (SOAR fogged in)	14:29	16:39	2:11	0:30	Yes	Flew Partenavia Observer. Heavy fog/low clouds delayed departure until afternoon. Conducted focal on feeding blue and fin whales again in same area as yesterday.
30-Jul	1	Partenavia OBS	N SOAR	13:45	16:05	2:20	1:11	No	N SOAR range open, flew over cloud cover to San Clemente then dropped and flew two N SOAR lines, flew over cloud cover return trip.
31-Jul	1	Partenavia OBS	S NAOPA (SOAR fogged in)	14:27	18:27	4:00	3:22	Yes	Heavy fog/low clouds delayed departure until afternoon. Focal on blue whales in NAOPA; SOAR fogged in/ inaccessible.
1-Aug	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No flight. Aircraft grounded due to mechanical issues
2-Aug	1	Partenavia OBS	Central NAOPA	14:45	17:52	3:07	2:37	Yes	Mechanic fixed plane by 1 pm. Flew N NAOPA lines. Focal on blue whales.
3-Aug	1	Partenavia OBS	N NAOPA	15:27	18:07	2:40	1:40	Yes	Extra unscheduled survey day in NAOPA. Heavy fog/low clouds delayed departure until afternoon. Low clouds all day limited ability to do an effective focal.
Totals						**19:23**	**12:16**		

Table 2. Aerial survey flight times, total hours (hh:mm) by date, and survey area during the September 2010 SOCAL aerial survey.

Date 2010	Flight	Platform	Location	Time Lift Off	Time Landed	Total Flight Time	Total "On Effort" Observ	MTE-assoc. MFAS?	Survey Notes
23-Sep	0	Partenavia OBS	n/a	14:10	14:12	0:02	n/a	n/a	Upon take-off pilot decided to land again to redistribute weight in plane.
23-Sep	1	Partenavia OBS	S NAOPA	14:20	17:33	3:13	3:06	Yes	Completed 4 southernmost NAOPA lines, relatively few sightings compared to previous surveys.
24-Sep	1	Partenavia OBS	N SOAR	11:42	14:57	3:15	3:10	No	First survey flight flew straight to N SOAR did 4 N legs at SOAR then flew back; fog nearshore on way in morning, no observing until partway through transit. Focal on blue whale and common dolphins. Saw many bait balls today and N elephant seal and common dolphins feeding on bait balls.
24-Sep	2	Partenavia OBS	Coastal NAOPA	16:05	17:41	1:36	1:46	No	Flew N about 10 nm from shore, hit Bf 5, then turned back and headed S about 5 nm offshore and went in. Saw many feeding common dolphins and bait balls.
25-Sep	1	Partenavia OBS	NE SOAR	10:19	13:37	3:18	3:13	No	Headed straight out to T2 in NE SOAR where BRS vessel was this morning; did not circle any groups on way out to save fuel for coordination with BRS and to maximize time on SOAR. Flew 4 northernmost SOAR transect lines. Bf 2 most of day. Unusually high number of common dolphins seen feeding, also bait balls seen.
26-Sep	1	Partenavia OBS	N SOAR	10:35	14:18	3:43	3:36	No	Flew straight to N SOAR since BRS vessel restricted to N SOAR. Communications with BRS requested that we help them relocate Cuvier's beaked whales. We circled at 1+ km from BRS' Cascadia tag boat looking for Cuvier's with them. Then we flew mini N-S transect lines in NW SOAR to look for other sightings that we reported to BRS vessel which was still busy with Cuvier's.
26-Sep	2	Partenavia OBS	Coastal NAOPA	15:24	17:25	2:01	1:54	No	Headed N parallel to shore by about 8 nm, did focals on unusual synchronized foraging behavior by common dolphins seen frequently only this survey period. Flew 2 NAOPA lines

Date 2010	Flight	Platform	Location	Time Lift Off	Time Landed	Total Flight Time	Total "On Effort" Observ	MTE-assoc. MFAS?	Survey Notes
27-Sep	1	Partenavia OBS	N SOAR	9:38	13:34	3:56	3:49	Yes	Flew straight over to N SOAR Line 1 flew this line E to W then talked to BRS and they asked us to help them find whales just N of SOAR Range in NW corner and to locate a beaked whale so we flew there and flew improvised systematic lines 1 nm apart paralleling SOAR lines and 3 nm long; saw 3 minkes and BRS had seen 2 minkes earlier this morning. Did focals on 2 groups of Risso's before and after seeing BRS vessel-- may have been same group check photos. VERY HOT in plane today, 95 degrees. Focal on Risso's dolphins and minke whales.
27-Sep	2	Partenavia OBS	W NAOPA	14:37	16:32	1:55	1:48	Yes	Headed W on NAOPA Line 4 to SCI then headed N along underwater drop off to try and locate sightings for BRS since they can't be on SOAR tomorrow. Focal on common dolphins.
28-Sep	1	Partenavia OBS	Coastal NAOPA	8:44	11:02	2:18	2:11	No	Headed N with goal to meet BRS in SC Basin and help them locate animals; however, airspace ended up being restricted so could not meet them to the W. Refueled at Oxnard.
28-Sep	2	Partenavia OBS	N NAOPA	11:55	15:14	3:19	3:12	No	Took off from Oxnard airport and did two lines in NAOPA; did focal on 3 sei/Bryde's whales lunge feeding (unusual sighting and behavior).
Totals						**28:34**	**27:45**		

Table 3. Definitions of leg types flown during the July and September 2010 aerial surveys.

Leg Type	Leg Type Definition
Systematic	Pre-determined line-transect legs located in SOAR, NAOPA and FLETA HOT
Random	Short lines connecting longer systematic lines
Transiting	Flying between the airport and the survey grid locations
Navy-Directed Transiting	Flying off intended course as directed by Navy during a survey to avoid Navy activities
Circling	Flying clockwise circles around sightings to verify species and group size via photography and/or to conduct focal behavioral sessions with videography as possible
Circumnavigating Coast	Flying parallel to SCI coastline approximately 0.5 km offshore to search for potential strandings
Fog Effort	Transiting above fog layer with limited or no visibility to water

Table 4. Summary of aerial survey effort (km and nm) by leg type during the July and September 2010 surveys.[1]/

Leg Type	July 2010			September 2010		
	Total km flown	Total nm Flown	Total hrs Flown	Total km Flown	Total nm Flown	Total hrs Flown
Systematic	592	320	3	1428	771	7.5
Random	111	60	0.5	164	89	1
Transiting	654	353	3.8	2345	1267	10.6
Navy-Directed Transiting	0	0	0	0	0	0
Circling	1549	836	10	1377	744	7.9
Circumnavigating Coast	0	0	0	0	0	0
Fog Effort	220	119	0.9	0	0	0
TOTAL	**3125**	**1688**	**18.1**	**5314**	**2871**	**27.0**

[1]/ Excludes flying over land to and from airport to water's edge.

Table 5. Summary of marine mammal sightings by species during the July SOCAL 2010 aerial surveys. Sightings organized in order of frequency observed starting with those seen most commonly.

Species Identification (Common Name)	Scientific Name	Total No. of Sightings	Total Estimated No. Individuals
Common Dolphin sp.	*Delphinus* sp.	40	9,354
Blue Whale	*Balaenoptera musculus*	18	44
Unidentified Dolphin	Delphinidae sp.	17	1,392
Fin Whale	*Balaenoptera physalus*	4	7
Common Bottlenose Dolphin	*Tursiops truncatus*	3	62
Unidentified Small Dolphin	Delphinidae sp.	2	220
California Sea Lion	*Zalophus californianus*	1	2
Risso's Dolphin	*Grampus griseus*	1	9
Totals		**86**	**11,090**

Table 6. Summary of marine mammal sightings by species during the September SOCAL 2010 aerial surveys.

Species Identification (Common Name)	Scientific Name	Total No. of Sightings	Total Estimated No. Individuals
Common Dolphin sp.	*Delphinus* sp.	124	34,136
California Sea Lion	*Zalophus californianus*	71	194
Unidentified Dolphin	Delphinidae sp.	32	3,380
Risso's Dolphin	*Grampus griseus*	6	74
Common Bottlenose Dolphin	*Tursiops truncatus*	4	48
Northern Elephant Seal	*Mirounga angustirostris*	3	22
Unidentified Marine Mammal	Cetacea or Pinnipedia	2	9
Unidentified Baleen Whale	*Balaenoptera* sp.	2	2
Unidentified Medium Marine Mammal	Cetacea or Pinnipedia	2	1
Long-beaked Common Dolphin	*Delphinus capensis*	1	9
Minke Whale	*Balaenoptera acutorostrata*	1	3
Bryde's/Sei Whale	*Balaenoptera borealis/edeni*	1	3
Cuvier's Beaked Whale	*Ziphius cavirostris*	1	2
Bryde's Whale	*Balaenoptera brydei/edeni*	1	1
Unidentified Small Marine Mammal	Cetacea or Pinnipedia	1	1
Totals		**252**	**37,874**

Table 7. Notable differences in the seasonal sighting encounter rates of marine mammal species during the May, July and September 2010 aerial surveys in SOCAL.

Species and Description
During July 2010 only, sighting rates were highest for common dolphins and blue whales based on both number of groups and individuals per km and hr. Other species were seen at considerably lower sighting rates due to fewer sightings per unit effort.
Sighting rates of Risso's dolphins were remarkably higher in May than in November and July, with May being the highest (n=432).
Sighting rates for individual common dolphins were roughly three times higher in July and November vs. May. In September, sighting rates for common dolphins were almost four times higher than July.
Blue whale sighting rates were also highest in July, were considerably lower for May and were absent during the September survey.
Pacific white-sided dolphins and California sea lions were absent or virtually absent in July as expected (Carretta et al. 2000).
Bottlenose dolphins were not seen in November.
Fin whale sighting rates were similar across May and July but none were seen in September survey.
Minke whales were last sighted in July 2009 and November, each with one sighting. Sightings for September were three individuals.
Bryde's whales were only seen during two of the eight surveys, October 2008 and September, each with one individual sighting. A sei/Bryde's whale sighting (n=3 individuals in one group) only occurred in September; two other surveys, November 2008 and July 2009, had possible fin or sei sightings.
Sightings rates for California sea lions in September were roughly 100 times higher than July due to the fact that they were absent or virtually absent in July.
Northern elephant seals were absent in all surveys except one individual sighting in November 2008 and September. Sighting rates for individual Northern elephant seals for September were roughly 20 times greater than the single sighting in November 2008.

1 *Table 8. Unusual and relatively rare observations made during the July and September 2010 SOCAL*
2 *aerial surveys.*

Date in 2010	Species	Description
27 July	Blue Whale Mother and Calf #1	A mother and calf (young-of-the-year) blue whale pair was circled form 15:24-16:24. We have rarely seen blue whale calves during our seven SOCAL aerial surveys. Video was taken on this part from 15:51-16:24. The interesting aspect of this encounter was that the calf appeared to be nursing from the mother based on review of the video. After a series of surfacing and blows, the calf dove below the mother who was at the time visible below the water surface. The pair appears to rest/float just below the water surface for a short period with the calf oriented towards the mother's ventral surface as the mother appeared to roll o her side.
28 July	Blue-Fin Whale Interaction	We circled a loose grouping of blue and fin whales, and gathered data on surfacing/respiration and inter-individual spacing (i.e., dispersal) parameters of traveling blue whales, yet to be analyzed. Our last behavioral description/video sequence of the day was for a scene of 8 min 24 sec in the afternoon from 15:45:54 – 15:54:18. Observations were hampered a bit by glare and thus the inability to stay with focal animals in parts of the circles around them. There were three blue and three fin whales. At least five of them, probably all six with one underwater, were as close as one whale body length (BL) from each other during part of one circling by the plane. All the whales were traveling, but brief social interactions were noted among the three fin whales. It is possible, but not presently demonstrated, that there were at least brief social interactions among the fin and blue whales, i.e., between species. One particularly interesting observation stands out. It lasted for only 24 seconds. We linked descriptions of the behaviors with 8 still shots pulled off video, in order as AA29, then A39 through G53. These numbers refer to arbitrary seconds into the 6th minute of the scene as described below. The encounter described involved feeding blue and fin whales focused around a bait ball of presumably euphausiid prey. This encounter appeared to involve inter-specific social interactions and/or potential competition for food.
2 August	Blue Whale Mother and Calf #2	A blue whale mother and calf and another adult were circled from the airplane from 16:56 to 17:28. A total of 38 min of video was taken. The calf was more active at the surface than we have previously seen among blue whales in SOCAL. All three whales breached, and the calf breached and rolled at the surface on multiple occasions as recorded on video. In one episode, the mother lunged and breached followed by the calf breaching and lunging five times and then the par dove. A third adult then lunged twice and breached. The calf resurfaced and continued breaching numerous times as the mother was observed traveling below the water surface nearby.

Date in 2010	Species	Description
24 September	Bryde's Whale	At 13:56:15, a single Bryde's whale was seen. Initially, this whale was not identified to species; however, subsequent examination of photographs showed three prominent rostral ridges and species was confirmed by Dr. Tom Jefferson. The Bryde's whale had only been seen once before during the October 2008 SOCAL aerial monitoring survey.
25 September	Northern Elephant Seal	We circled a group of five northern elephant seals at 11:55:00 for ~3 minutes. The seals stayed near or at the surface through the entire sighting. Northern elephant seals had not been identified during any other of the previous seven SOCAL Marine Species Monitoring Plan (SMSPM) aerial surveys, except in November 2008 (1 group, 1 individual).
26 September	Cuvier's Beaked Whale	At 12:00 a group of two Cuvier's beaked whales was seen blowing at the surface and traveling slowly in the opposite direction from the Cascadia Research Collective rigid-hulled inflatable research boat that was ~25 m away. We circled them at 1 to 1.5 km (0.5 to 0.8 nm) radius to not interfere with the whales (well outside Snell's cone, at 304 m (1000 ft) altitude). Dr. Brandon Southall had asked us to aid in sighting cetaceans for their ongoing SOCAL Behavioral Response Study (BRS), in particular helping to resight the Cuvier's beaked whales. Other sightings of Cuvier's beaked whale occurred during the July 09 (1 group, 4 individuals) and November 09 (2 groups, 6 individuals) SOCAL aerial monitoring surveys.
28 September	Sei/Bryde's Whale	Initially seen mostly underwater as it fluked up, a sei or Bryde's whale was seen at 9:41:30. We circled the sighting and subsequently saw three whales in the group. We watched for ~30 minutes while the whales sporadically lunge fed including on their sides (see report cover photograph). Photographs of this sighting were taken and were reviewed by Dr. Tom Jefferson who confirmed the whales were either sei or Bryde's whales, based primarily on the lack of white on the right jaw, body length, head shape, body coloration, and the possibility of three rostral ridges on the head. Additional photograph angles may have allowed species differentiation based on dorsal shape and size and the rostral ridges

Table 9. Comparison of Aircraft Platforms to Collect Behavioral Data on Marine Mammals.

Aircraft Type	Partenavia P68-C	Partenavia P68-OBS ("Observer")	Helicopter
Plane Tail Numbers/ Models	300LK and 32K (P68c)--no glass nose	6602L ("Observer" with glass nose)	Bell 206 LIII
Maximum Range	4.5 hr (if remove 100 lbs. of cargo/person would have 5.5 hours--e.g., equipmt? Smaller observers?)	4.0 hr (if remove 100 lbs. of cargo/person would have 5.0 hours--e.g., equipmt? Smaller observers?)	2.6 hr
Approx Cost per Hr	$550	$550	$1450/hr
Slowest Safe Apprx. Circling Speed	80 kt	80 kt	~45 -50 kt
Windows	• small porthole (~5 inches diameter) in co-pilot seat but difficult to use/requires some contortion; • middle seats have bubble windows (bad for photo/video /binocs due to distortion); • during future IDIQ surveys 2 pilots will be required and thus co-pilot seat will not be available for biological observers; • rear 3rd bench windows have small opening but exhaust fumes distort this view that is easily blocked by cowling/wing when plane turns; • has belly window	• same as for P68-C; • glass nose increases visibility in front seats; • has belly window	• large (12 x 12 inch) sliding windows in co-pilot and two rear seats; • large concave windows provide better view than Partenavias in rear of aircraft
Advantages	• 300 LK is best range aircraft of Partenavias • big tires allow more weight to be carried • can drop sonobuoy from belly window	• Easier for pilot to spot and circle sightings than other Partenavias due to glass nose • can drop sonobuoy from belly window	• Floats allow offshore surveys; • Large open windows allow good view and excellent photo/video conditions; • slower circle speed allows longer/better view of whales to video/photo; • easier for pilot to keep animals in view;

Aircraft Type	Partenavia P68-C	Partenavia P68-OBS ("Observer")	Helicopter
Disadvantages	• no glass nose; • only co-pilot seat small porthole opens; • cost and time (FAA approval) to remove/replace window); • bubble windows distort image; • cowlings partially block view especially in rear 3rd seat; • rear 3rd seat view distorted by exhaust fumes	• shorter range than other Partenavia; • bubble windows distort image; • only small porthole opens in front and rear seats; • bubble windows distort image; • cowlings partially block view especially in rear 3rd seat; • rear 3rd seat view distorted by exhaust fumes; • cost and time (FAA approval) to remove/replace windows	• Expense is nearly 3x that of Partenavia; • Short range (about half that of Partenavias) • SOAR SOCAL range is too far to survey unless helicopter & crew/observers stationed and fueled on San Clemente Isld; • requires more maintenance than fixed wings
Potential Improvements/ Mitigation?	Could remove bubble center seat windows and replace with opening windows or no window(s)	same as other Partenavia	if use helo on standby on SCI could potentially share/cut costs; Aspen flies both this helo and the partenavias
When Used for Navy Surveys	SOCAL Nov 08, June/July 09, Nov 09, May 10	Oct 08, Jul 10	Jul 10

Table 10. Summary of SOCAL Marine Mammal Aerial Surveys.

	Survey								
	October	**November**	**June**	**July**	**November**	**May**	**July**	**September**	**Total**
Survey Dates	17-21 Oct 2008	15-18 Nov 2008	5-11 June 2009	20-29 July 2009	18-23 Nov 2009	13-18 May	27 July-3 Aug	23-28 Sept 2010	**8 surveys: May, June, July, Oct, Nov**
No. Days Flown	5	4	6	9	6	6	7	6	**49**
Major Training Exercise (MTE) Before, During or After Survey?	Before/During	After	After	After	During/After	During	During/After	During/After	**During, Before or After**
Total Flight Hr (Wheels up/down)	28	21	30	34	28	29	18	28	**216**
Total Observation Effort (km) *(excl. poor weather, over land)*	4563 km (2464 nm)	3838 km (2072 nm)	6140 km (3315 nm)	6500 km (3510 nm)	4823 km (2604 nm)	4891 km (2641 nm)	3125 km (1688 nm)	3918 km (2116 nm)	**37,798 (20,410)**
No. Navy-directed Survey Changes (appox)	9	7	12	10	3	1	0	0	**42**
No. Coastline Surveys for Strandings (San Clemente Isld)	0	2	1	0	1	1	0	0	**5**
No. Groups Seen	115	185	161	240	93	152	86	252	**1,284**
Estim. No. Individuals	12,587	5732	9489	22,719	12,826	5,453	11,090	37,874	**117,770**
Mean Group Size	109.4	31	58.9	94.7	137.9	35.9	131.3	150.3	**91.7**
No. Dead Sightings	0	3 (2 CA sea lions, 1 blue whale)	0	2 (2 prob. CA sea lions)	0	0	0	0	**5**
No. Species	9	9	11	10	10	9	5	9	**16 total species seen**

	Survey								
	October	**November**	**June**	**July**	**November**	**May**	**July**	**September**	**Total**
No. Focal Groups Circled 5-9 min	22	20	24	37	14	10	6	6	**139**
No. Extended Focal Groups Circled >10 min	5	7	7	8	10	20	13	10	**80**
Longest Focal Follow Duration	29 min (*Fin whale*)	60 min (*Fin whale*)	48 min (*Fin whale*)	38 min (*Long-beaked common dolphin*)	40 min (*Killer whale*)	144 min (*Fin whale*)	59 min (Blue whale)	45 min (Bryde's Whale)	**144 min. (longest focal from all surveys)**
No. Photos Taken	1050	1280	1099	2301	2203	1350	2900	741	**12,924**
Estimated Usable Video (min)	53	41	83	50	90	334	373	142	**1166**

Appendix A. List of Sightings

Table A-1. Sightings during SOCAL 2010 July aerial monitoring surveys off San Diego, California.

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
07/27/2010	14:09:01	Blue Whale	*Balaenoptera musculus*	4	32.89900	-117.32050
07/27/2010	14:16:15	Common Bottlenose Dolphin	*Tursiops truncatus*	50	32.92833	-117.31067
07/27/2010	14:47:30	Fin Whale	*Balaenoptera physalus*	1	32.93383	-117.33550
07/27/2010	15:23:46	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.82733	-117.37233
07/27/2010	15:24:19	Blue Whale	*Balaenoptera musculus*	6	32.82867	-117.37883
07/27/2010	16:21:15	Fin Whale	*Balaenoptera physalus*	2	32.83817	-117.38783
07/28/2010	13:43:11	Common Bottlenose Dolphin	*Tursiops truncatus*	6	32.88150	-117.28067
07/28/2010	13:46:21	Blue Whale	*Balaenoptera musculus*	3	32.93283	-117.31550
07/28/2010	14:06:22	Unidentified Small Dolphin	unidentified Delphinidae	20	32.92500	-117.30483
07/28/2010	14:40:04	Blue Whale	*Balaenoptera musculus*	1	33.01400	-117.38767
07/28/2010	14:42:26	Blue Whale	*Balaenoptera musculus*	1	33.05750	-117.38783
07/28/2010	14:44:00	Common Bottlenose Dolphin	*Tursiops truncatus*	6	33.08383	-117.40000
07/28/2010	14:56:06	Common Dolphin sp.	undifferentiated *Delphinus*	400	33.18500	-117.46033
07/28/2010	15:13:48	Common Dolphin sp.	undifferentiated *Delphinus*	60	33.08583	-117.48517
07/28/2010	15:16:50	Common Dolphin sp.	undifferentiated *Delphinus*	600	33.02833	-117.47383
07/28/2010	15:31:50	Unidentified Small Dolphin	unidentified Delphinidae	200	32.72617	-117.34750
07/28/2010	15:44:38	Common Dolphin sp.	undifferentiated *Delphinus*	200	32.62367	-117.35150
07/28/2010	15:45:58	Blue Whale	*Balaenoptera musculus*	5	32.64333	-117.34600
07/28/2010	15:45:58	Fin Whale	*Balaenoptera physalus*	3	32.64533	-117.34717
07/29/2010	14:37:26	Blue Whale	*Balaenoptera musculus*	2	32.75583	-117.36200
07/29/2010	15:50:41	Common Dolphin sp.	undifferentiated *Delphinus*	380	33.04883	-117.38033
07/29/2010	16:05:57	Common Dolphin sp.	undifferentiated *Delphinus*	110	33.15700	-117.47383
07/29/2010	16:13:49	Common Dolphin sp.	undifferentiated *Delphinus*	40	33.07517	-117.46250
07/29/2010	16:14:22	Blue Whale	*Balaenoptera musculus*	1	33.05783	-117.45033
07/29/2010	16:15:16	Common Dolphin sp.	undifferentiated *Delphinus*	60	33.03717	-117.43617
07/29/2010	16:19:58	Blue Whale	*Balaenoptera musculus*	3	32.92300	-117.34733
07/30/2010	15:08:36	Risso's Dolphin	*Grampus griseus*	9	33.11183	-118.65333
07/31/2010	14:31:55	Common Dolphin sp.	undifferentiated *Delphinus*	600	32.86100	-117.28500
07/31/2010	14:35:46	Common Dolphin sp.	undifferentiated *Delphinus*	100	32.76233	-117.35683
07/31/2010	14:36:31	Blue Whale	*Balaenoptera musculus*	6	32.73800	-117.36700
07/31/2010	15:44:29	Common Dolphin sp.	undifferentiated *Delphinus*	100	32.66533	-117.54267

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
07/31/2010	15:50:33	Common Dolphin sp.	undifferentiated *Delphinus*	200	32.63283	-117.74500
07/31/2010	16:07:24	Common Dolphin sp.	undifferentiated *Delphinus*	60	32.74817	-117.65483
07/31/2010	16:21:53	Unidentified Dolphin	unidentified Delphinidae	25	32.81583	-117.42633
07/31/2010	16:32:32	Common Dolphin sp.	undifferentiated *Delphinus*	12	32.89733	-117.36683
07/31/2010	16:46:05	Common Dolphin sp.	undifferentiated *Delphinus*	110	32.90317	-117.53317
07/31/2010	17:22:26	Common Dolphin sp.	undifferentiated *Delphinus*	15	32.97783	-117.74033
07/31/2010	17:30:45	Unidentified Dolphin	unidentified Delphinidae	1	33.01517	-117.57950
07/31/2010	17:33:13	Common Dolphin sp.	undifferentiated *Delphinus*	125	33.02150	-117.54183
07/31/2010	17:37:33	Common Dolphin sp.	undifferentiated *Delphinus*	40	33.03033	-117.50417
07/31/2010	17:41:12	Common Dolphin sp.	undifferentiated *Delphinus*	450	33.05467	-117.38017
07/31/2010	17:41:32	Blue Whale	*Balaenoptera musculus*	1	33.05667	-117.36817
07/31/2010	17:41:32	Fin Whale	*Balaenoptera physalus*	1	33.05667	-117.36817
07/31/2010	18:20:41	Unidentified Dolphin	unidentified Delphinidae	90	32.87600	-117.27733
08/02/2010	14:49:42	California Sea Lion	*Zalophus californianus*	2	32.86100	-117.26233
08/02/2010	14:51:25	Blue Whale	*Balaenoptera musculus*	2	32.90717	-117.28417
08/02/2010	14:53:04	Blue Whale	*Balaenoptera musculus*	1	32.91217	-117.30517
08/02/2010	14:53:04	Common Dolphin sp.	undifferentiated *Delphinus*	300	32.91217	-117.30517
08/02/2010	15:02:45	Common Dolphin sp.	undifferentiated *Delphinus*	40	32.98350	-117.32167
08/02/2010	15:03:33	Common Dolphin sp.	undifferentiated *Delphinus*	35	33.00733	-117.33500
08/02/2010	15:09:36	Unidentified Dolphin	unidentified Delphinidae	75	33.12800	-117.42733
08/02/2010	15:15:32	Unidentified Dolphin	unidentified Delphinidae	120	33.12217	-117.63100
08/02/2010	15:55:32	Blue Whale	*Balaenoptera musculus*	2	33.18833	-117.92983
08/02/2010	16:47:54	Unidentified Dolphin	unidentified Delphinidae	200	33.26650	-117.58817
08/02/2010	16:48:19	Common Dolphin sp.	undifferentiated *Delphinus*	55	33.27883	-117.59067
08/02/2010	16:53:12	Common Dolphin sp.	undifferentiated *Delphinus*	175	33.28233	-117.59717
08/02/2010	16:56:05	Blue Whale	*Balaenoptera musculus*	2	33.31483	-117.62500
08/02/2010	17:19:09	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.33083	-117.61433
08/02/2010	17:29:49	Unidentified Dolphin	unidentified Delphinidae	50	33.27050	-117.56150
08/02/2010	17:32:21	Common Dolphin sp.	undifferentiated *Delphinus*	250	33.20567	-117.50200
08/02/2010	17:33:57	Common Dolphin sp.	undifferentiated *Delphinus*	70	33.16583	-117.48283
08/02/2010	17:36:39	Unidentified Dolphin	unidentified Delphinidae	125	33.09400	-117.42833
08/02/2010	17:37:31	Unidentified Dolphin	unidentified Delphinidae	50	33.07317	-117.41050
08/03/2010	15:32:41	Common Dolphin sp.	undifferentiated *Delphinus*	*	32.89717	-117.28583
08/03/2010	15:33:39	Blue Whale	*Balaenoptera musculus*	1	32.92717	-117.29900
08/03/2010	15:35:22	Common Dolphin sp.	undifferentiated *Delphinus*	25	32.93200	-117.30533
08/03/2010	15:36:42	Common Dolphin sp.	undifferentiated *Delphinus*	40	32.96767	-117.33000
08/03/2010	15:42:06	Common Dolphin sp.	undifferentiated *Delphinus*	1000	33.11417	-117.44150
08/03/2010	15:52:18	Common Dolphin sp.	undifferentiated *Delphinus*	*	33.19333	-117.50950
08/03/2010	15:55:05	Common Dolphin sp.	undifferentiated *Delphinus*	600	33.21533	-117.50883

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
08/03/2010	15:57:43	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.25683	-117.57017
08/03/2010	15:59:00	Common Dolphin sp.	undifferentiated *Delphinus*	*	33.25833	-117.56967
08/03/2010	16:02:29	Common Dolphin sp.	undifferentiated *Delphinus*	1100	33.29600	-117.61367
08/03/2010	16:04:07	Common Dolphin sp.	undifferentiated *Delphinus*	350	33.33267	-117.64617
08/03/2010	16:06:11	Common Dolphin sp.	undifferentiated *Delphinus*	400	33.37000	-117.69683
08/03/2010	16:07:32	Common Dolphin sp.	undifferentiated *Delphinus*	250	33.36600	-117.73617
08/03/2010	16:23:44	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.25083	-118.25333
08/03/2010	16:47:03	Unidentified Dolphin	unidentified Delphinidae	125	33.33900	-118.23733
08/03/2010	16:59:54	Unidentified Dolphin	unidentified Delphinidae	70	33.45633	-117.90867
08/03/2010	17:03:26	Unidentified Dolphin	unidentified Delphinidae	140	33.45400	-117.78983
08/03/2010	17:07:10	Unidentified Dolphin	unidentified Delphinidae	50	33.43317	-117.76483
08/03/2010	17:07:38	Unidentified Dolphin	unidentified Delphinidae	200	33.42233	-117.75267
08/03/2010	17:09:21	Unidentified Dolphin	unidentified Delphinidae	*	33.38367	-117.71100
08/03/2010	17:10:52	Unidentified Dolphin	unidentified Delphinidae	25	33.35183	-117.67233
08/03/2010	17:12:01	Unidentified Dolphin	unidentified Delphinidae	35	33.32767	-117.64167
08/03/2010	17:14:31	Common Dolphin sp.	undifferentiated *Delphinus*	7	33.26983	-117.58017
08/03/2010	17:18:17	Unidentified Dolphin	unidentified Delphinidae	11	33.25067	-117.55650
08/03/2010	17:26:16	Unidentified Dolphin	unidentified Delphinidae	*	33.05417	-117.39117
08/03/2010	17:27:28	Common Dolphin sp.	undifferentiated *Delphinus*	120	33.01917	-117.37450
08/03/2010	17:31:06	Blue Whale	*Balaenoptera musculus*	1	32.91200	-117.31867
08/03/2010	17:34:51	Blue Whale	*Balaenoptera musculus*	2	32.92117	-117.31967

* Individual animal counts for these sightings are pending further survey data analysis.

Table A-2. Sightings during SOCAL 2010 September aerial monitoring surveys off San Diego, California.

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/23/2010	15:11:00	Common Dolphin sp.	undifferentiated *delphinus*	25	32.768	-117.575333
9/23/2010	15:29:00	Common Dolphin sp.	undifferentiated *delphinus*	6	32.92483333	-117.405500
9/23/2010	15:54:10	Unidentified Medium Marine Mammal	unidentified marine mammal	1	32.7905	-118.012000
9/23/2010	16:07:25	Common Dolphin sp.	undifferentiated *delphinus*	15	32.81333333	-118.231500
9/23/2010	16:08:30	California Sea Lion	*Zalophus californianus*	1	32.81683333	-118.217000
9/23/2010	16:16:17	Common Dolphin sp.	undifferentiated *delphinus*	60	32.87733333	-118.247333
9/23/2010	16:30:00	Common Dolphin sp.	undifferentiated *delphinus*	700	32.90483333	-118.113667
9/23/2010	16:54:22	Common Dolphin sp.	undifferentiated *delphinus*	600	33.017	-117.326500
9/23/2010	16:57:00	Bottlenose Dolphin	*Tursiops truncatus*	2	32.9515	-117.309500
9/23/2010	16:59:08	Common Dolphin sp.	undifferentiated *delphinus*	80	32.89966667	-117.316000
9/23/2010	17:09:16	Common Dolphin sp.	undifferentiated *delphinus*	200	32.65516667	-117.303833
9/23/2010	17:09:55	Common Dolphin sp.	undifferentiated *delphinus*	300	32.64183333	-117.291333
9/23/2010	17:15:00	Bottlenose Dolphin	*Tursiops truncatus*	3	32.5535	-117.253833
9/23/2010	17:21:23	Common Dolphin sp.	undifferentiated *delphinus*	315	32.70166667	-117.341333
9/23/2010	17:24:33	Common Dolphin sp.	undifferentiated *delphinus*	40	32.787	-117.363667
9/24/2010	12:02:47	Unidentified Medium Marine Mammal	unidentified marine mammal	1	33.00333333	-117.995667
9/24/2010	12:08:00	Unidentified Dolphin	unidentified Delphinidae	250	33.04516667	-118.207667
9/24/2010	12:09:26	Common Dolphin sp.	undifferentiated *delphinus*	100	33.05783333	-118.271333
9/24/2010	12:09:55	Unidentified Dolphin	unidentified Delphinidae	1000	33.06233333	-118.297167
9/24/2010	12:17:40	Bottlenose Dolphin	*Tursiops truncatus*	25	33.12833333	-118.622000
9/24/2010	12:21:08	California Sea Lion	*Zalophus californianus*	1	33.167	-118.804500
9/24/2010	12:28:21	Common Dolphin sp.	undifferentiated *delphinus*	375	33.08733333	-119.006167
9/24/2010	12:36:32	Unidentified Marine Mammal	unidentified marine mammal	4	33.03216667	-119.110167
9/24/2010	12:36:47	California Sea Lion	*Zalophus californianus*	2	33.02883333	-119.118000
9/24/2010	12:38:15	Common Dolphin sp.	undifferentiated *delphinus*	75	33.018	-119.135667
9/24/2010	12:39:06	Common Dolphin sp.	undifferentiated *delphinus*	70	32.999	-119.169500
9/24/2010	12:39:50	Common Dolphin sp.	undifferentiated *delphinus*	125	32.9915	-119.183000
9/24/2010	12:40:17	California Sea Lion	*Zalophus californianus*	30	32.9785	-119.206333
9/24/2010	12:40:27	Unidentified Dolphin	unidentified Delphinidae	4	32.9785	-119.206333
9/24/2010	12:42:19	California Sea Lion	*Zalophus californianus*	4	32.94633333	-119.247167
9/24/2010	12:42:56	California Sea Lion	*Zalophus californianus*	*	32.93216667	-119.235667
9/24/2010	12:43:02	California Sea Lion	*Zalophus californianus*	3	32.93216667	-119.235667
9/24/2010	12:43:34	California Sea Lion	*Zalophus californianus*	1	32.93216667	-119.235667
9/24/2010	12:43:57	California Sea Lion	*Zalophus californianus*	1	32.91366667	-119.220167
9/24/2010	12:44:16	Common Dolphin sp.	undifferentiated *delphinus*	*	32.902	-119.210500
9/24/2010	12:49:01	California Sea Lion	*Zalophus californianus*	1	32.916	-119.183167

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/24/2010	12:50:01	California Sea Lion	*Zalophus californianus*	2	32.93133333	-119.158667
9/24/2010	12:50:10	California Sea Lion	*Zalophus californianus*	*	32.93133333	-119.158667
9/24/2010	12:51:18	Unidentified Marine Mammal	unidentified marine mammal	5	32.952	-119.123667
9/24/2010	12:57:07	Northern Elephant Seal	*Mirounga angustirostris*	5	32.96733333	-119.124333
9/24/2010	13:06:27	California Sea Lion	*Zalophus californianus*	*	33.0025	-119.034333
9/24/2010	13:08:27	California Sea Lion	*Zalophus californianus*	1	33.02966667	-118.983667
9/24/2010	13:12:26	California Sea Lion	*Zalophus californianus*	1	33.09316667	-118.866500
9/24/2010	13:14:21	California Sea Lion	*Zalophus californianus*	2	33.12266667	-118.814667
9/24/2010	13:22:00	California Sea Lion	*Zalophus californianus*	1	33.08183333	-118.740500
9/24/2010	13:23:18	California Sea Lion	*Zalophus californianus*	2	33.06066667	-118.781167
9/24/2010	13:25:22	Common Dolphin sp.	undifferentiated *delphinus*	2	33.02566667	-118.845833
9/24/2010	13:31:24	California Sea Lion	*Zalophus californianus*	25	33.00816667	-118.887667
9/24/2010	13:34:44	California Sea Lion	*Zalophus californianus*	4	32.956	-118.984167
9/24/2010	13:42:13	Unidentified Baleen Whale	unidentified balaenopterid	1	32.8385	-119.149000
9/24/2010	13:48:48	California Sea Lion	*Zalophus californianus*	1	32.806	-119.116000
9/24/2010	13:48:51	California Sea Lion	*Zalophus californianus*	1	32.806	-119.116000
9/24/2010	13:51:48	California Sea Lion	*Zalophus californianus*	2	32.84883333	-119.044000
9/24/2010	13:51:58	California Sea Lion	*Zalophus californianus*	1	32.85666667	-119.030667
9/24/2010	13:52:10	California Sea Lion	*Zalophus californianus*	1	32.85666667	-119.030667
9/24/2010	13:52:39	California Sea Lion	*Zalophus californianus*	1	32.86683333	-119.013167
9/24/2010	13:52:42	California Sea Lion	*Zalophus californianus*	1	32.86683333	-119.013167
9/24/2010	13:53:17	California Sea Lion	*Zalophus californianus*	2	32.86683333	-119.013167
9/24/2010	13:53:54	California Sea Lion	*Zalophus californianus*	2	32.88083333	-118.988000
9/24/2010	13:54:54	California Sea Lion	*Zalophus californianus*	1	32.90366667	-118.948500
9/24/2010	13:55:04	California Sea Lion	*Zalophus californianus*	2	32.90366667	-118.948500
9/24/2010	13:55:43	California Sea Lion	*Zalophus californianus*	4	32.917	-118.925000
9/24/2010	13:56:13	Bryde's Whale	*Balaenoptera brydei/edeni*	1	32.917	-118.925000
9/24/2010	14:03:00	California Sea Lion	*Zalophus californianus*	1	33.00466667	-118.768500
9/24/2010	14:03:36	California Sea Lion	*Zalophus californianus*	1	33.01616667	-118.749000
9/24/2010	14:03:46	California Sea Lion	*Zalophus californianus*	1	33.01616667	-118.749000
9/24/2010	14:05:24	California Sea Lion	*Zalophus californianus*	*	33.0445	-118.695500
9/24/2010	14:05:54	California Sea Lion	*Zalophus californianus*	*	33.04416667	-118.687333
9/24/2010	14:07:31	California Sea Lion	*Zalophus californianus*	*	33.03616667	-118.622000
9/24/2010	14:07:56	California Sea Lion	*Zalophus californianus*	*	33.03616667	-118.622000
9/24/2010	14:16:30	Common Dolphin sp.	undifferentiated *delphinus*	250	32.99216667	-118.317833
9/24/2010	14:22:43	Risso's Dolphin	*Grampus griseus*	2	32.99466667	-118.277833
9/24/2010	14:22:44	Unidentified Dolphin	unidentified Delphinidae	15	32.99466667	-118.277833
9/24/2010	14:27:21	Common Dolphin sp.	undifferentiated *delphinus*	300	32.97266667	-118.192000
9/24/2010	14:30:22	Unidentified Dolphin	unidentified Delphinidae	5	32.95833333	-118.087000

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/24/2010	14:31:15	California Sea Lion	*Zalophus californianus*	1	32.95366667	-118.054667
9/24/2010	14:31:42	California Sea Lion	*Zalophus californianus*	1	32.95366667	-118.054667
9/24/2010	14:33:05	Common Dolphin sp.	undifferentiated *delphinus*	400	32.9475	-118.002833
9/24/2010	14:33:11	Common Dolphin sp.	undifferentiated *delphinus*	400	32.9435	-117.977833
9/24/2010	14:37:26	Common Dolphin sp.	undifferentiated *delphinus*	50	32.9225	-117.834000
9/24/2010	14:38:13	Common Dolphin sp.	undifferentiated *delphinus*	200	32.91816667	-117.808167
9/24/2010	14:39:09	Common Dolphin sp.	undifferentiated *delphinus*	6	32.91383333	-117.777833
9/24/2010	14:42:26	California Sea Lion	*Zalophus californianus*	1	32.89666667	-117.658167
9/24/2010	16:11:00	Common Dolphin sp.	undifferentiated *delphinus*	400	32.912	-117.347500
9/24/2010	16:16:00	Common Dolphin sp.	undifferentiated *delphinus*	100	33.02083333	-117.489333
9/24/2010	16:18:00	Common Dolphin sp.	undifferentiated *delphinus*	*	33.03483333	-117.494333
9/24/2010	16:21:00	Common Dolphin sp.	undifferentiated *delphinus*	30	33.06866667	-117.542167
9/24/2010	16:22:00	Common Dolphin sp.	undifferentiated *delphinus*	200	33.084	-117.567500
9/24/2010	16:37:00	Common Dolphin sp.	undifferentiated *delphinus*	300	33.35766667	-117.915333
9/24/2010	16:59:00	Common Dolphin sp.	undifferentiated *delphinus*	40	33.41233333	-117.861000
9/24/2010	17:05:00	Unidentified Dolphin	unidentified Delphinidae	150	33.38366667	-117.807167
9/24/2010	17:09:00	Common Dolphin sp.	undifferentiated *delphinus*	300	33.3095	-117.683000
9/24/2010	17:12:00	Common Dolphin sp.	undifferentiated *delphinus*	300	33.30233333	-117.659000
9/24/2010	17:13:00	Long-Beaked Common Dolphin	*Delphinus capensis*	9	33.28483333	-117.628167
9/24/2010	17:18:00	Common Dolphin sp.	undifferentiated *delphinus*	300	33.24483333	-117.577500
9/24/2010	17:21:00	Common Dolphin sp.	undifferentiated *delphinus*	75	33.18416667	-117.490833
9/24/2010	17:25:00	Common Dolphin sp.	undifferentiated *delphinus*	70	33.13866667	-117.452667
9/25/2010	10:33:00	Common Dolphin sp.	undifferentiated *delphinus*	700	32.945	-117.678500
9/25/2010	10:33:01	Risso's Dolphin	*Grampus griseus*	10	32.945	-117.678500
9/25/2010	10:39:01	Unidentified Dolphin	unidentified Delphinidae	19	32.98733333	-117.890833
9/25/2010	10:44:50	Common Dolphin sp.	undifferentiated *delphinus*	20	33.02883333	-118.097167
9/25/2010	10:54:00	Unidentified Dolphin	unidentified Delphinidae	75	33.0935	-118.425667
9/25/2010	11:01:00	Common Dolphin sp.	undifferentiated *delphinus*	350	33.14233333	-118.676333
9/25/2010	11:07:00	California Sea Lion	*Zalophus californianus*	1	33.15266667	-118.887333
9/25/2010	11:07:10	Common Dolphin sp.	undifferentiated *delphinus*	1100	33.15266667	-118.887333
9/25/2010	11:09:00	Unidentified Dolphin	unidentified Delphinidae	400	33.14433333	-118.938667
9/25/2010	11:18:00	Common Dolphin sp.	undifferentiated *delphinus*	15	33.05016667	-119.078167
9/25/2010	11:38:00	California Sea Lion	*Zalophus californianus*	1	33.095	-118.865000
9/25/2010	11:40:00	Common Dolphin sp.	undifferentiated *delphinus*	100	33.12666667	-118.807667
9/25/2010	11:47:00	Common Dolphin sp.	undifferentiated *delphinus*	400	33.126	-118.697500
9/25/2010	11:55:00	Northern Elephant Seal	*Mirounga angustirostris*	11	33.02966667	-118.848333
9/25/2010	12:03:00	Northern Elephant Seal	*Mirounga angustirostris*	6	32.96183333	-118.973000
9/25/2010	12:17:00	California Sea Lion	*Zalophus californianus*	35	32.85616667	-119.038167
9/25/2010	12:30:00	California Sea Lion	*Zalophus californianus*	2	33.0245	-118.735000

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/25/2010	12:33:00	Common Dolphin sp.	undifferentiated *delphinus*	1200	33.05166667	-118.628667
9/25/2010	12:41:00	Common Dolphin sp.	undifferentiated *delphinus*	1600	33.09733333	-118.330667
9/25/2010	12:52:00	Common Dolphin sp.	undifferentiated *delphinus*	150	33.155	-118.082333
9/25/2010	13:02:00	Common Dolphin sp.	undifferentiated *delphinus*	110	33.19183333	-117.921333
9/25/2010	13:02:10	Unidentified Dolphin	unidentified Delphinidae	50	33.19183333	-117.921333
9/25/2010	13:06:00	Common Dolphin sp.	undifferentiated *delphinus*	100	33.201	-117.882333
9/25/2010	13:22:00	Common Dolphin sp.	undifferentiated *delphinus*	75	33.06433333	-117.384000
9/25/2010	13:24:00	Common Dolphin sp.	undifferentiated *delphinus*	200	33.0615	-117.360000
9/25/2010	13:28:00	Unidentified Dolphin	unidentified Delphinidae	40	32.966	-117.311500
9/25/2010	13:29:00	Unidentified Dolphin	unidentified Delphinidae	8	32.93416667	-117.306167
9/26/2010	10:46:19	Unidentified Dolphin	unidentified Delphinidae	1	32.945	-117.550333
9/26/2010	10:50:32	Unidentified Dolphin	unidentified Delphinidae	30	32.97	-117.728667
9/26/2010	10:52:21	Common Dolphin sp.	undifferentiated *delphinus*	20	32.98166667	-117.803000
9/26/2010	10:53:36	Common Dolphin sp.	undifferentiated *delphinus*	40	32.9915	-117.849333
9/26/2010	10:55:25	Common Dolphin sp.	undifferentiated *delphinus*	125	33.0055	-117.923333
9/26/2010	11:02:57	Common Dolphin sp.	undifferentiated *delphinus*	200	33.06416667	-118.220667
9/26/2010	11:04:57	Unidentified Dolphin	unidentified Delphinidae	20	33.078	-118.301000
9/26/2010	11:09:15	Unidentified Dolphin	unidentified Delphinidae	2	33.10983333	-118.475833
9/26/2010	11:11:08	Common Dolphin sp.	undifferentiated *delphinus*	200	33.12466667	-118.549667
9/26/2010	11:11:30	Common Dolphin sp.	undifferentiated *delphinus*	60	33.12683333	-118.563333
9/26/2010	11:12:56	Common Dolphin sp.	undifferentiated *delphinus*	400	33.138	-118.625000
9/26/2010	12:00:00	Cuvier's Beaked Whale	*Ziphius cavirostris*	2	32.84183333	-119.150333
9/26/2010	12:43:14	California Sea Lion	*Zalophus californianus*	1	32.9795	-119.189667
9/26/2010	12:58:16	Unidentified Dolphin	unidentified Delphinidae	15	32.94583333	-119.254167
9/26/2010	13:13:30	Common Dolphin sp.	undifferentiated *delphinus*	1000	33.175	-118.846500
9/26/2010	13:43:17	California Sea Lion	*Zalophus californianus*	2	33.1685	-118.685333
9/26/2010	13:47:47	Common Dolphin sp.	undifferentiated *delphinus*	75	33.11733333	-118.487500
9/26/2010	13:59:01	Unidentified Dolphin	unidentified Delphinidae	24	33.01716667	-117.969500
9/26/2010	14:01:53	Unidentified Dolphin	unidentified Delphinidae	150	32.9765	-117.842167
9/26/2010	14:02:34	Common Dolphin sp.	undifferentiated *delphinus*	50	32.96666667	-117.812167
9/26/2010	14:09:11	Common Dolphin sp.	undifferentiated *delphinus*	250	32.88683333	-117.504333
9/26/2010	14:10:10	Common Dolphin sp.	undifferentiated *delphinus*	550	32.87683333	-117.458167
9/26/2010	15:35:00	Unidentified Dolphin	unidentified Delphinidae	70	33.03066667	-117.436667
9/26/2010	15:36:00	Unidentified Dolphin	unidentified Delphinidae	4	33.0565	-117.458500
9/26/2010	15:37:55	Common Dolphin sp.	undifferentiated *delphinus*	190	33.09633333	-117.513833
9/26/2010	15:47:00	Common Dolphin sp.	undifferentiated *delphinus*	100	33.32066667	-117.697167
9/26/2010	15:48:21	Common Dolphin sp.	undifferentiated *delphinus*	90	33.357	-117.722333
9/26/2010	16:01:01	Common Dolphin sp.	undifferentiated *delphinus*	450	33.374	-118.032500
9/26/2010	16:10:39	Common Dolphin sp.	undifferentiated *delphinus*	75	33.41466667	-118.014667
9/26/2010	16:19:29	Unidentified Dolphin	unidentified Delphinidae	125	33.2675	-118.302667
9/26/2010	16:53:35	Common Dolphin sp.	undifferentiated *delphinus*	400	33.129	-117.421500
9/27/2010	9:45:00	Unidentified Dolphin	unidentified Delphinidae	50	32.8965	-117.326667

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/27/2010	9:54:58	Common Dolphin sp.	undifferentiated *delphinus*	2100	32.959	-117.788500
9/27/2010	9:55:00	Common Dolphin sp.	undifferentiated *delphinus*	550	32.959	-117.788500
9/27/2010	9:56:00	Common Dolphin sp.	undifferentiated *delphinus*	200	32.96633333	-117.834833
9/27/2010	9:57:00	Common Dolphin sp.	undifferentiated *delphinus*	150	32.97383333	-117.880833
9/27/2010	10:05:25	Unidentified Dolphin	unidentified Delphinidae	60	33.06966667	-118.257833
9/27/2010	10:06:29	Common Dolphin sp.	undifferentiated *delphinus*	2200	33.09116667	-118.294667
9/27/2010	10:11:14	California Sea Lion	*Zalophus californianus*	2	33.13433333	-118.497667
9/27/2010	10:17:19	Common Dolphin sp.	undifferentiated *delphinus*	250	33.17733333	-118.755667
9/27/2010	10:18:06	Common Dolphin sp.	undifferentiated *delphinus*	200	33.18233333	-118.785333
9/27/2010	10:19:22	Common Dolphin sp.	undifferentiated *delphinus*	25	33.18016667	-118.828833
9/27/2010	10:24:46	California Sea Lion	*Zalophus californianus*	1	33.09483333	-118.994500
9/27/2010	10:25:51	Common Dolphin sp.	undifferentiated *delphinus*	50	33.07866667	-119.025000
9/27/2010	10:46:42	California Sea Lion	*Zalophus californianus*	1	33.1285	-119.207667
9/27/2010	10:47:00	California Sea Lion	*Zalophus californianus*	1	33.137	-119.213167
9/27/2010	10:48:12	Risso's Dolphin	*Grampus griseus*	30	33.165	-119.227667
9/27/2010	11:15:41	California Sea Lion	*Zalophus californianus*	2	33.06183333	-119.368833
9/27/2010	11:16:55	California Sea Lion	*Zalophus californianus*	2	33.08083333	-119.343167
9/27/2010	11:23:30	Unidentified Small Marine Mammal	unidentified marine mammal	1	33.04083333	-119.299500
9/27/2010	11:27:28	California Sea Lion	*Zalophus californianus*	1	33.039	-119.274000
9/27/2010	11:29:58	California Sea Lion	*Zalophus californianus*	1	33.06883333	-119.214667
9/27/2010	11:35:46	California Sea Lion	*Zalophus californianus*	1	33.00183333	-119.233000
9/27/2010	11:36:10	California Sea Lion	*Zalophus californianus*	1	33.01183333	-119.223833
9/27/2010	11:37:18	California Sea Lion	*Zalophus californianus*	1	33.03616667	-119.204167
9/27/2010	11:38:11	California Sea Lion	*Zalophus californianus*	1	33.04566667	-119.183667
9/27/2010	11:50:24	California Sea Lion	*Zalophus californianus*	1	33.05833333	-119.233000
9/27/2010	11:51:24	California Sea Lion	*Zalophus californianus*	2	33.03733333	-119.252667
9/27/2010	11:52:01	California Sea Lion	*Zalophus californianus*	1	33.023	-119.264500
9/27/2010	11:55:13	Minke Whale	*Balaenoptera acutorostrata*	3	33.01866667	-119.326833
9/27/2010	12:00:00	California Sea Lion	*Zalophus californianus*	1	33.0155	-119.318667
9/27/2010	12:11:00	California Sea Lion	*Zalophus californianus*	1	33.05766667	-119.317333
9/27/2010	12:12:00	California Sea Lion	*Zalophus californianus*	5	33.037	-119.338167
9/27/2010	12:16:18	California Sea Lion	*Zalophus californianus*	2	33.118	-119.279333
9/27/2010	12:16:59	California Sea Lion	*Zalophus californianus*	1	33.13	-119.264333
9/27/2010	12:19:27	California Sea Lion	*Zalophus californianus*	1	33.14866667	-119.191833
9/27/2010	12:21:15	Risso's Dolphin	*Grampus griseus*	8	33.148	-119.128500
9/27/2010	12:45:15	Common Dolphin sp.	undifferentiated *delphinus*	100	33.16266667	-118.900000
9/27/2010	12:56:51	California Sea Lion	*Zalophus californianus*	4	33.08283333	-118.429167
9/27/2010	13:00:21	Common Dolphin sp.	undifferentiated *delphinus*	350	33.10783333	-118.288000
9/27/2010	13:01:00	Common Dolphin sp.	undifferentiated *delphinus*	40	33.11133333	-118.260167
9/27/2010	13:04:40	Common Dolphin sp.	undifferentiated *delphinus*	605	33.145	-118.109167
9/27/2010	13:11:46	Common Dolphin sp.	undifferentiated *delphinus*	180	33.20033333	-117.813833

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/27/2010	13:13:10	Common Dolphin sp.	undifferentiated *delphinus*	40	33.21533333	-117.750167
9/27/2010	13:16:44	Common Dolphin sp.	undifferentiated *delphinus*	55	33.253	-117.597167
9/27/2010	13:17:49	Common Dolphin sp.	undifferentiated *delphinus*	450	33.24783333	-117.547167
9/27/2010	13:22:00	Unidentified Dolphin	unidentified Delphinidae	100	33.13216667	-117.432000
9/27/2010	13:24:00	Common Dolphin sp.	undifferentiated *delphinus*	300	33.0705	-117.389667
9/27/2010	13:25:00	Common Dolphin sp.	undifferentiated *delphinus*	850	33.03883333	-117.369167
9/27/2010	13:27:01	Unidentified Dolphin	unidentified Delphinidae	250	32.973	-117.333667
9/27/2010	13:28:20	Common Dolphin sp.	undifferentiated *delphinus*	750	32.92783333	-117.313167
9/27/2010	14:46:46	Common Dolphin sp.	undifferentiated *delphinus*	650	32.905	-117.288667
9/27/2010	14:48:20	Common Dolphin sp.	undifferentiated *delphinus*	125	32.9535	-117.319167
9/27/2010	14:50:13	Common Dolphin sp.	undifferentiated *delphinus*	50	33.00716667	-117.353000
9/27/2010	14:50:35	Common Dolphin sp.	undifferentiated *delphinus*	350	33.02116667	-117.362500
9/27/2010	14:51:30	Common Dolphin sp.	undifferentiated *delphinus*	75	33.044	-117.378000
9/27/2010	14:52:48	Common Dolphin sp.	undifferentiated *delphinus*	60	33.05033333	-117.417833
9/27/2010	14:57:14	Common Dolphin sp.	undifferentiated *delphinus*	12	33.01916667	-117.560333
9/27/2010	14:57:25	Common Dolphin sp.	undifferentiated *delphinus*	275	33.018	-117.566000
9/27/2010	15:01:05	Common Dolphin sp.	undifferentiated *delphinus*	40	33.01166667	-117.609667
9/27/2010	15:01:45	Common Dolphin sp.	undifferentiated *delphinus*	90	33.00683333	-117.630667
9/27/2010	15:02:30	Common Dolphin sp.	undifferentiated *delphinus*	135	33.0015	-117.652667
9/27/2010	15:17:17	Common Dolphin sp.	undifferentiated *delphinus*	30	32.98616667	-117.717500
9/27/2010	15:19:42	Common Dolphin sp.	undifferentiated *delphinus*	50	32.97366667	-117.785667
9/27/2010	15:27:44	Common Dolphin sp.	undifferentiated *delphinus*	1299	32.92566667	-118.025000
9/27/2010	15:27:53	Common Dolphin sp.	undifferentiated *delphinus*	70	32.92566667	-118.025000
9/27/2010	16:15:54	Unidentified Dolphin	unidentified Delphinidae	25	32.98366667	-117.551500
9/27/2010	16:19:51	Common Dolphin sp.	undifferentiated *delphinus*	505	33.0105	-117.426667
9/27/2010	16:24:24	Common Dolphin sp.	undifferentiated *delphinus*	450	32.9305	-117.318167
9/28/2010	8:49:00	Unidentified Dolphin	unidentified Delphinidae	1	32.88266667	-117.298333
9/28/2010	8:55:00	Unidentified Baleen Whale	unidentified balaenopterid	1	33.033	-117.442500
9/28/2010	8:58:27	Common Dolphin sp.	undifferentiated *delphinus*	600	33.04166667	-117.446333
9/28/2010	9:32:59	Common Dolphin sp.	undifferentiated *delphinus*	150	33.1005	-117.519333
9/28/2010	9:41:30	Sei/Bryde’s Whale	*Balaenoptera borealis/edeni/brydei*	3	33.27733333	-117.796000
9/28/2010	10:00:00	Unidentified Dolphin	unidentified Delphinidae	500	33.31366667	-117.798000
9/28/2010	10:27:45	Unidentified Dolphin	unidentified Delphinidae	8	33.42816667	-117.996833
9/28/2010	11:58:52	Unidentified Dolphin	unidentified Delphinidae	8	34.16033333	-119.328667
9/28/2010	12:20:37	Common Dolphin sp.	undifferentiated *delphinus*	100	34.038	-119.159833
9/28/2010	12:47:14	Common Dolphin sp.	undifferentiated *delphinus*	10	33.62366667	-118.260500
9/28/2010	12:53:20	Common Dolphin sp.	undifferentiated *delphinus*	80	33.54316667	-118.032833
9/28/2010	12:55:07	Common Dolphin sp.	undifferentiated *delphinus*	400	33.5205	-117.961500
9/28/2010	13:17:57	Unidentified Dolphin	unidentified Delphinidae	50	33.44666667	-117.950000
9/28/2010	13:19:28	Common Dolphin sp.	undifferentiated *delphinus*	15	33.43733333	-118.001167

Sighting Date	Sighting Time	Common Name	Species	Best Count	Latitude	Longitude
9/28/2010	13:20:50	Risso's Dolphin	*Grampus griseus*	25	33.429	-118.045333
9/28/2010	13:47:13	Common Dolphin sp.	undifferentiated *delphinus*	75	33.41966667	-118.108500
9/28/2010	13:50:13	Risso's Dolphin	Grampus griseus	1	33.4	-118.209667
9/28/2010	13:56:02	Common Dolphin sp.	undifferentiated *delphinus*	15	33.31833333	-118.226167
9/28/2010	13:58:04	Common Dolphin sp.	undifferentiated *delphinus*	25	33.2915	-118.286333
9/28/2010	14:01:58	Common Dolphin sp.	undifferentiated *delphinus*	200	33.24866667	-118.404167
9/28/2010	14:14:27	Common Dolphin sp.	undifferentiated delphinus	60	33.229	-118.367500
9/28/2010	14:17:54	Common Dolphin sp.	undifferentiated delphinus	100	33.256	-118.250333
9/28/2010	14:19:26	Bottlenose Dolphin	Tursiops truncatus	18	33.267	-118.201833
9/28/2010	14:26:26	California Sea Lion	undifferentiated *delphinus*	40	33.25916667	-118.213167
9/28/2010	14:43:30	Common Dolphin sp.	undifferentiated *delphinus*	12	33.34166667	-117.854167
9/28/2010	14:46:46	Common Dolphin sp.	undifferentiated *delphinus*	42	33.36466667	-117.739500
9/28/2010	14:54:18	Common Dolphin sp.	undifferentiated *delphinus*	750	33.24866667	-117.541833
9/28/2010	15:06:25	Common Dolphin sp.	undifferentiated delphinus	5	32.93133333	-117.316167
9/28/2010	15:07:35	Common Dolphin sp.	undifferentiated delphinus	550	32.899	-117.298833

* Individual animal counts for these sightings are pending further survey data analysis.

Appendix B. Sighting Rates

Table B-1. Sighting rates of marine mammal groups by species during the November 2009, May 2010, July 2010, and September 2010 SOCAL aerial surveys during systematic, random and transit effort.

Species (Common Name)	Nov-09				May-10				Jul-10				Sep-10			
	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr
Whales																
Blue Whale	0	0	0	0	2	0.0007	0.001	0.072	18	0.0058	0.026	0.99	0	0	0	0
Fin Whale	5	0.001	0.003	0.19	2	0.0007	0.001	0.072	4	0.0013	0.0024	0.22	0	0	0	0
Sei Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Bryde's Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Minke Whale	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0	1	0.0003	0.0005	0.05
Unidentified Baleen Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Unidentified Large Whale	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0	0	0	0	0
Unidentified Medium Whale	1	0.0003	0.0005	0.037	0	0	0	0	0	0	0	0	0	0	0	0
Dolphins																
Killer Whale	2	0.0006	0.001	0.075	0	0	0	0	0	0	0	0	0	0	0	0
Cuvier's Beaked Whale	2	0.0006	0.001	0.075	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Risso's Dolphin	5	0.001	0.003	0.19	28	0.14	0.02	1.011	1	0.00032	0.00059	0.06	6	0.002	0.003	0.32
Common Dolphin sp.	25	0.007	0.013	0.94	15	1.27	0.01	0.54	40	0.013	0.024	2.21	125	0.032	0.06	6.6
Bottlenose Dolphin	0	0	0	0	9	0.98	0.006	0.32	3	0.00096	0.0018	0.17	4	0.001	0.002	0.21
Pacific White-sided Dolphin	6	0.002	0.003	0.22	2	0.03	0.001	0.072	0	0	0	0	0	0	0	0
Unidentified Dolphin	6	0.002	0.003	0.22	10	0.27	0.007	0.361	17	0.0054	0.01	0.94	32	0.008	0.015	1.7
Unidentified Small Dolphin	2	0.0006	0.001	0.075	4	0.17	0.003	0.14	2	0.00064	0.0012	0.11	0	0	0	0
Pinnipeds																
California Sea Lion	19	0.006	0.01	0.71	22	0.02	0.016	0.79	1	0.00032	0.00059	0.06	71	0.018	0.034	3.7
Harbor Seal	0	0	0	0	1	0.0007	0.0007	0.036	0	0	0	0	0	0	0	0
Northern Elephant Seal	0	0	0	0	0	0	0	0	0	0	0	0	3	0.0008	0.0014	0.16
Unidentified Pinniped	4	0.001	0.002	0.15	2	0.0007	0.001	0.072	0	0	0	0	0	0	0	0
Unidentified Marine Mammal	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0	2	0.0005	0.0009	0.11
Unidentified Small Marine Mammal	1	0.0003	0.0005	0.037	2	0.0007	0.001	0.072	0	0	0	0	1	0.0003	0.0005	0.05
Unidentified Medium Marine Mammal	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0005	0.0009	0.11
Overall Marine Mammal	**81**	**0.02**	**0.04**	3.034	**102**	**0.04**	**0.073**	3.68	**86**	**0.028**	**0.051**	**4.75**	**251**	**0.065**	**0.12**	**13.3**

Table B-2. Sighting rates of individual marine mammals by species during the November 2009, May, July 2010 and September 2010 SOCAL aerial surveys during systematic, random and transit effort.

Species (Common Name)	Nov-09				May-10				Jul-10				Sep-10			
	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr	Total No. of Sightings	Sightings /km	Sightings /nm	Sightings /hr
Whales																
Blue Whale	0	0	0	0	2	0.0007	0.001	0.072	18	0.0058	0.026	0.99	0	0	0	0
Fin Whale	5	0.001	0.003	0.19	2	0.0007	0.001	0.072	4	0.0013	0.0024	0.22	0	0	0	0
Sei Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Bryde's Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Minke Whale`	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0	1	0.0003	0.0005	0.05
Unidentified Baleen Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Unidentified Large Whale	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0	0	0	0	0
Unidentified Medium Whale	1	0.0003	0.0005	0.037	0	0	0	0	0	0	0	0	0	0	0	0
Dolphins																
Killer Whale	2	0.0006	0.001	0.075	0	0	0	0	0	0	0	0	0	0	0	0
Cuvier's Beaked Whale	2	0.0006	0.001	0.075	0	0	0	0	0	0	0	0	1	0.0003	0.0005	0.05
Risso's Dolphin	5	0.001	0.003	0.19	28	0.14	0.02	1.011	1	0.00032	0.00059	0.06	6	0.002	0.003	0.32
Common Dolphin sp.	25	0.007	0.013	0.94	15	1.27	0.01	0.54	40	0.013	0.024	2.21	125	0.032	0.06	6.6
Bottlenose Dolphin	0	0	0	0	9	0.98	0.006	0.32	3	0.00096	0.0018	0.17	4	0.001	0.002	0.21
Pacific White-sided Dolphin	6	0.002	0.003	0.22	2	0.03	0.001	0.072	0	0	0	0	0	0	0	0
Unidentified Dolphin	6	0.002	0.003	0.22	10	0.27	0.007	0.361	17	0.0054	0.01	0.94	32	0.008	0.015	1.7
Unidentified Small Dolphin	2	0.0006	0.001	0.075	4	0.17	0.003	0.14	2	0.00064	0.0012	0.11	0	0	0	0
Pinnipeds																
California Sea Lion	19	0.006	0.01	0.71	22	0.02	0.016	0.79	1	0.00032	0.00059	0.06	71	0.018	0.034	3.7
Harbor Seal	0	0	0	0	1	0.0007	0.0007	0.036	0	0	0	0	0	0	0	0
Northern Elephant Seal	0	0	0	0	0	0	0	0	0	0	0	0	3	0.0008	0.0014	0.16
Unidentified Pinniped	4	0.001	0.002	0.15	2	0.0007	0.001	0.072	0	0	0	0	0	0	0	0
Unidentified Marine Mammal	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0	2	0.0005	0.0009	0.11
Unidentified Small Marine Mammal	1	0.0003	0.0005	0.037	2	0.0007	0.001	0.072	0	0	0	0	1	0.0003	0.0005	0.05
Unidentified Medium Marine Mammal	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0005	0.0009	0.11
Overall Marine Mammal	**81**	**0.02**	**0.04**	3.034	**102**	**0.04**	**0.073**	3.68	**86**	**0.028**	**0.051**	**4.75**	**252**	**0.065**	**0.12**	**13.3**

Table B-3. Sighting rates of marine mammal (MM) groups by effort type during the November 2009, May 2010, July 2010 and September 2010 SOCAL aerial surveys.

Effort Type	Species Group	Nov 18-23, 2009							May 13-18, 2010							July 27- August 3, 2010							September 23-28, 2010						
		Total Stgs	Total km	Total nm	Total hr	Sighting/km	Sighting/nm	Sighting/hr	Total Stgs	Total km	Total nm	Total hr	Sighting/km	Sighting/nm	Sighting/hr	Total Stgs	Total km	Total nm	Total hr	Sighting/km	Sighting/nm	Sighting/hr	Total Stgs	Total km	Total nm	Total hr	Sighting/km	Sighting/nm	Sighting/hr
Systematic	Whales	6	1790	967	8.25	0.003	0.006	0.73	4	1268	685	7.26	0.003	0.006	0.5509	1	592	319.68	3	0.002	0.003	0.33	**1**	1428	771	7.5	0.0007	0.0013	0.133
	Dolphins	21				0.012	0.022	2.55	29				0.023	0.042	3.9939	13				0.022	0.041	4.33	49				0.034	0.064	6.533
	Pinnipeds	17				0.009	0.018	2.06	13				0.01	0.019	1.7904	0				0	0	0	49				0.034	0.064	6.533
	All MM	44				**0.025**	**0.046**	5.33	**46**				**0.036**	**0.067**	6.3351	**14**				0.024	0.044	4.67	99				0.069	0.128	13.2
Random	Whales	0	669	361	1.72	0	0	0	1	370	200	2.1	0.003	0.005	0.4768	0	111	59.94	0.5	0	0	0	2	164	89	1	0.012	0.022	2
	Dolphins	4				0.006	0.011	2.33	10				0.027	0.05	4.76821	3				0.027	0.050	6.00	7				0.043	0.079	7
	Pinnipeds	3				0.004	0.008	1.75	1				0.003	0.005	0.4768	0				0	0	0	9				0.055	0.101	9
	All MM	7				**0.01**	**0.019**	4.08	**12**				**0.032**	**0.06**	5.7219	**3**				0.027	0.050	6.00	18				0.182	0.54	18
Transit	Whales	**2**	983	531	3.73	0.002	0.004	0.54	1	956	516	4.53	0.001	0.002	0.2206	16	874	471.96	3.8	0.018	0.034	4.21	2	2286	1234	10.4	0.0009	0.0016	0.1923
	Dolphins	23				0.023	0.043	6.17	29				0.03	0.056	6.3971	42				0.048	0.089	11.05	109				0.0477	0.0883	10.5
	Pinnipeds	3				0.003	0.006	0.81	12				0.013	0.023	2.6471	1				0.001	0.002	0.26	11				0.0048	0.0089	1.058
	All MM	**28**				**0.028**	**0.053**	7.51	**42**				**0.044**	**0.081**	9.2647	**59**				0.068	0.125	15.53	122				0.0533	0.099	11.73
Circling	Whales	0	1335	721	7.2	0	0	0	0	2125	1147	12.91	0	0	0	5	1549	836.46	10	0.003	0.006	0.50	1	50	27	0.3	0.02	0.037	3.33
	Dolphins	1				0.001	0.001	0.14	0				0	0	0	5				0.003	0.006	0.50	2				0.04	0.074	6.66
	Pinnipeds	0				0	0	0	0				0	0	0	0				0	0	0	5				0.1	0.185	16.66
	All MM	**1**				**0.001**	**0.001**	0.14	**0**				**0**	**0**	0	**10**				0.006	0.012	1.00	8				0.16	0.297	26.66
Circumnavigating San Clemente Island	Whales	0	120	65	0.21	0	0	0	0	83	45	0.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dolphins	2				0.017	0.031	9.33	3				0.036	0.067	6.2791	0				0	0	0	0				0	0	0
	Pinnipeds	5				0	0	23.32	37				0.446	0.826	77.4419	0				0	0	0	0				0	0	0
	All MM	**7**				**0.058**	**0.108**	32.64	**40**				**0.482**	**0.893**	83.7209	**0**				0	0	0	0				0	0	0
Navy-directed Transiting	Whales	0	137	74	0.63	0	0	0	0	91	49	0.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dolphins	1				0.007	0.014	1.58	7				0.077	0.142	17.7465	0				0	0	0	0				0	0	0
	Pinnipeds	4				0	0	6.34	3				0.033	0.061	7.6056	0				0	0	0	0				0	0	0
	All MM	**5**				**0.036**	**0.068**	7.92	**10**				**0.11**	**0.204**	25.3521	**0**				0	0	0	0				0	0	0

Table B-4. Sighting rates of individual marine mammals (MM) by effort type during the November 2009, May 2010, July 2010 and September 2010 SOCAL aerial surveys.

Effort Type	Species Group	Nov 18-23, 2009							May 13-18, 2010							July 27- August 3, 2010							September 23-28, 2010						
		Total Indiv	Total km	Total nm	Total hr	Indiv/ km	Indiv/ nm	Indiv/ hr	Total Indiv	Total km	Total nm	Total hr	Indiv/km	Individual/ nm	Individual/hr	Total Animals	Total km	Total nm	Total hr	Individual /km	Individual/ nm	Individual /hr	Total Animals	Total km	Total nm	Total hr	Individual/ km	Individual/ nm	Individual/ hr
Systematic	Whales	4	1790	967	8.25	0.0022	0.0041	0.48	6	1268	685	7.26	0.0047	0.0088	0.83	2	592	319.68	3	0.003	0.006	0.67	1	1428	771	7.5	0.0007	0.0013	0.1333
	Dolphins	3823				2.14	3.95	463.5	3080				2.43	4.5	424.18	1841				3.110	5.759	613.67	10119				7.09	13.12	1349.2
	Pinnipeds	8				0.0045	0.0083	0.97	20				0.016	0.029	2.75	0				0.000	0.000	0.00	151				0.106	0.196	20.133
	All MM	3835				2.14	3.97	464.96	3106				2.45	4.53	427.76	1843				3.113	5.765	614.33	10271				7.19	13.32	1369.5
Random	Whales	8	669	361	1.72	0.012	0.022	4.66	1	370	200	2.1	0.0027	0.005	0.477	0	111	59.94	0.5	0.000	0.000	0.00	4	164	89	1	0.024	0.045	4
	Dolphins	8207				12.27	22.73	4785.42	582				1.57	2.91	277.51	162				1.459	2.703	324.00	685				4.177	7.697	685
	Pinnipeds	77				0.12	0.21	44.9	25				0.068	0.125	11.92	0				0.000	0.000	0.00	13				0.079	0.146	13
	All MM	8292				12.39	22.97	4834.99	608				1.64	3.04	289.91	162				1.459	2.703	324.00	702				4.28	7.89	702
Transit	Whales	2	983	531	3.73	0.002	0.0038	0.54	1	956	516	4.53	0.001	0.0019	0.22	42	874	471.96	3.8	0.048	0.089	11.05	4	2286	1234	10.4	0.002	0.003	0.385
	Dolphins	3835				3.9	7.22	1029.22	1465				1.53	2.84	323.16	8564				9.799	18.146	2253.68	26065				11.4	21.12	2506.25
	Pinnipeds	3				0.0031	0.0056	0.81	18				0.019	0.035	3.97	2				0.002	0.004	0.53	10				0.004	0.008	0.96
	All MM	28				0.028	0.0527	7.51	1495				1.56	2.9	329.78	8608				9.849	18.239	2265.26	26079				11.4	21.13	2507.6
Circling	Whales	0	1335	721	7.2	0	0	0	0	2125	1147	12.91	0	0	0	7	1549	836.46	10	0.005	0.008	0.70	2	50	27	0.3	0.04	0.074	6.66
	Dolphins	150				0.11	0.2	20.84	0				0	0	0	470				0.303	0.562	47.00	900				18	33.33	3000
	Pinnipeds	0				0	0	0	0				0	0	0	0				0.000	0.000	0.00	48				0.96	1.77	160
	All MM	150				0.11	0.2	20.84	0				0	0	0	477				0.308	0.570	47.70	950				19	35.19	3166.7
Circumnavigating San Clemente Island	Whales	0	120	65	0.21	0	0	0	0	83	45	0.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dolphins	50				0.42	0.77	233.16	53				0.64	1.18	110.93	0				0	0	0	0				0	0	0
	Pinnipeds	35				0.29	0.54	163.21	96				1.16	2.13	200.93	0				0	0	0	0				0	0	0
	All MM	85				0.71	1.31	396.37	149				1.8	3.31	311.86	0				0	0	0	0				0	0	0
Navy-directed Transiting	Whales	0	137	74	0.63	0	0	0	0	91	49	0.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dolphins	447				3.26	6.041	707.96	90				0.99	1.84	228.17	0				0	0	0	0				0	0	0
	Pinnipeds	2				0.015	0.027	3.17	5				0.055	0.1	12.68	0				0	0	0	0				0	0	0
	All MM	449				3.28	6.068	711.13	95				1.044	1.94	240.85	0				0	0	0	0				0	0	0

Appendix C. Focal Follows

Table C-1. Focal follows performed during July SOCAL 2010 aerial monitoring surveys off San Diego, California.

Date	Start Time	End Time	Duration of Focal (hr:min:sec)	Latitude	Longitude	Species	Group Size	Notes
27-Jul	14:09:01	15:16:00	1:06:59	32.54065	117.19325	Blue Whale	4	
27-Jul	15:24:19	16:24:00	0:59:41	32.49768	117.22878	Blue Whale	6	One possible young-of-the year, 2 fins joined after period of time, 6 blues and 2 fins at the surface at one time in large 800-m circle
28-Jul	13:46:21	14:32:00	0:45:39	32.5597	117.18939	Blue Whale	3	
28-Jul	14:56:06	15:05:00	0:08:54	33.10959	117.27519	Common Dolphin sp.	400	
28-Jul	15:45:58	15:59:00	0:13:02	32.38722	117.20831	Blue Whale/Fin Whale	8	3 fin whales travel together with 3 blue whales, 2 other blue whales on the outskirts about 10 and 50 body lengths away
29-Jul	14:37:26	15:39:50	1:02:24	32.45351	117.21725	Blue Whale	2	
29-Jul	15:50:41	16:02:27	0:11:46	33.03163	117.23013	Common Dolphin sp.	380	
29-Jul	16:19:58	16:31:03	0:11:05	32.55137	117.2063	Blue Whale	3	
30-Jul	15:08:36	15:28:27	0:19:51	33.06714	118.39205	Risso's Dolphin	9	
31-Jul	14:35:36	15:40:07	1:04:31	32.45747	117.21411	Common Dolphin sp.	100	
31-Jul	14:36:31	15:40:21	1:03:50	32.44289	117.22023	Blue Whale	6	
31-Jul	15:50:33	15:56:10	0:05:37	32.37979	117.44703	Common Dolphin sp.	200	
31-Jul	16:07:24	16:16:01	0:08:37	32.44972	117.38886	Common Dolphin sp.	60	

Date	Start Time	End Time	Duration of Focal (hr:min:sec)	Latitude	Longitude	Species	Group Size	Notes
31-Jul	16:21:53	16:30:29	0:08:36	32.48956	117.25582	Unid. Dolphin	25	
31-Jul	16:46:05	16:52:28	0:06:23	32.5412	117.32314	Common Dolphin sp.	110	
31-Jul	17:41:12	18:15:06	0:33:54	33.03289	117.22819	Common Dolphin sp.	450	Fin whale in vicinity of single blue
2-Aug	16:56:05	17:28:36	0:32:31	33.19146	117.37712	Blue Whale	2	
3-Aug	15:42:06	15:49:00	0:06:54	33.07479	117.26426	Common Dolphin sp.	1000	
3-Aug	17:34:51	17:57:45	0:22:54	32.55495	117.19366	Blue Whale	2	Seen while circling the single blue whale seen earlier thus no angle; circled these 2 blues for focal session but clouds did not allow us to go any higher than 800 ft so we circled outside 1 km radial distance for short period but then determined that observations were not effective because too difficult to follow and resight whales at that low altitude due to wing getting in way and short period whales in view; seen near buoy

Number of 5 min-focals for July = 6

Number of 10-min focals for July = 13

Table C-2. Focal follows performed during September SOCAL 2010 aerial monitoring surveys off San Diego, California.

Date	Start Time	End Time	Duration of Focal (hr:min:sec)	Latitude	Longitude	Species	Group Size	Notes
24-Sep	13:42:13	13:48:48	0:06:35	32.839	-119.149	Unidentified Baleen Whale	1	Possibly a blue whale, very light
24-Sep	14:16:30	14:22:43	0:06:13	32.992	-118.318	Common Dolphin sp.	250	Very tight ball of dolphins travel fast with birds circled at 800 ft; see behavior sheet for 5 min focal
24-Sep	16:11:00	16:16:00	0:05:00	32.912	-117.348	Common Dolphin sp.	4000	
24-Sep	16:59:00	17:05:00	0:06:00	33.412	-117.861	Common Dolphin sp.	40	At least 4 subgroups, inverted swim, bird associated
26-Sep	13:13:30	13:42:00	0:28:30	33.175	-118.847	Common Dolphin sp.	1000	Circled for about 27 min took video and photos, Bernd used video regular lens then later put on UV lens thinks it helped some cutting back on the glare for video camera he thinks he got deeper into the water in no glare part of turns
26-Sep	16:01:01	16:10:00	0:08:59	33.337	-118.033	Common Dolphin sp.	450	
26-Sep	16:53:35	17:06:13	0:12:38	33. 129	-117.422	Common Dolphin sp.	400	Many subgroups of small groups of 5 to 12 or so, foraging, milling, some surface activity
27-Sep	10:48:12	11:09:00	0:20:48	33.165	-119.228	Risso's Dolphin	30	Headed up to 1500 ft. to do behaviors, slow travel entire time, we did focals on a group of about 17 Risso’s, see behavior sheet on this day; 10:50:44 we are telling R/V Sproul about location of Risso’s, but they are still with 1 beaked whale sighting

Date	Start Time	End Time	Duration of Focal (hr:min:sec)	Latitude	Longitude	Species	Group Size	Notes
27-Sep	11:55:13	12:02:00	0:06:47	33.019	-119.327	Minke Whale	3	3 small whales 1 confirmed with photo and view as minke, others are prob minkes too based on color under surface dark and size and behavior and synchrony MS LM saw chevron and white pec, Bernd got photos, Sproul saw 2 minkes this morning
27-Sep	12:21:15	12:44:00	0:22:45	33.148	-119.129	Risso's Dolphin	8	
27-Sep	15:02:30	15:14:00	0:11:30	33.002	-117.653	Common Dolphin sp.	135	doing focals w video because they are foraging and doing pirouetting circling; did focals on subgroup of about 12--see video
27-Sep	15:27:44	15:56:35	0:28:51	33.926	-118.025	Common Dolphin sp.	1299	Circling for photos and behavior 1 medium-sized recreational fishing vessel is following from about 0.5 nm
28-Sep	8:58:27	9:32:00	0:33:33	33.042	-117.446	Common Dolphin sp.	600	Spacer angle--commons feeding--photos trying to capture pairs feeding and distance between them
28-Sep	9:41:30	10:25:00	0:43:30	33.277	-117.796	Sei/Bryde's Whale	3	Initially seen underwater and fluking up, looked like a small or med size whale; we circled it for over 30 min while the whales sporadically lunge fed, Bernd got photos of lunge feeding, got photos of head and looks like there is a secondary ridge characteristic of Brydes whales. Bernd took circled at 030 degrees declination distance to animals at 1500 ft. T. Jefferson later examined photos and determined to be a sei or Bryde's whale

Date	Start Time	End Time	Duration of Focal (hr:min:sec)	Latitude	Longitude	Species	Group Size	Notes
28-Sep	13:20:50	13:45:00	0:24:10	33.429	-118.045	Risso's Dolphin	25	Did focals on a single Risso's for about 3+ surfacing sequences to get individual dive and blow times; BW got video, notes by LM on excel behavior sheet; was a single animal in this group, all individuals widely spread into subgroups of mostly 1-3 animals, a few subgroups of 5-10 indiv
28-Sep	14:26:26	14:34:46	0:08:20	33.259	-118.213	California Sea Lion	40	Resting at surface in tight group as we circled the bottlenose dolphins near Santa Catalina Isld; sea lions appeared to potentially react during third circling when plane passed over at about 70 degrees, some indiv diving with splash
		Total:	4:34:09					

Number of 5-min focals for September = 7

Number of 10-min focals for September = 9

Appendix D. List of July 2010 and September 2010 Video

Table D-1. Videos recorded during July SOCAL 2010 aerial monitoring surveys off San Diego, California.

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_27_SES_Video_141025-141438_ID01_Blue	7/27/2010	14:10:25	14:14:38	0:04:13	1	Blue Whale	4	Multiple blows, no vocals due to noise of helicopter, subsurface, 1 indiv.	BW
SOCAL_2010July_27_SES_Video_141538-141541_IDBoat_Boat	7/27/2010	14:15:38	14:15:41	0:00:03	Boat	Boat	1	Private sailboat only	BW
SOCAL_2010July_27_SES_Video_141610-141758_ID01_Bottlenose	7/27/2010	14:16:10	14:17:58	0:01:48	1	Bottlenose Dolphin	4	Fast travel, oriented at 350 degrees	BW
SOCAL_2010July_27_SES_Video_141828-141938_ID01_Bottlenose	7/27/2010	14:18:28	14:19:38	0:01:10	1	Bottlenose Dolphin	4	No audio, large group, fast travel	BW
SOCAL_2010July_27_SES_Video_142206-142658_ID01_Blue	7/27/2010	14:22:06	14:26:58	0:04:52	1	Blue Whale	4	1 indiv., below surface, multiple blows, slow travel, blew and dove	BW
SOCAL_2010July_27_SES_Video_143839-144109_ID01_Blue	7/27/2010	14:38:39	14:41:09	0:02:30	1	Blue Whale	4	below surface, 1 indiv., slow travel, blew and shallow dive	BW
SOCAL_2010July_27_SES_Video_144431-144520_ID01_Blue	7/27/2010	14:44:31	14:45:20	0:00:49	1	Blue Whale	4	1 indiv., below surface, blew and dove	BW
SOCAL_2010July_27_SES_Video_144703-144815_ID03_Fin	7/27/2010	14:47:03	14:48:15	0:01:12	3	Fin Whale	1	1 indiv, below surface, surfaces blows, and dives again and seen below surface	BW
SOCAL_2010July_27_SES_Video_145232-145253_ID01_Blue	7/27/2010	14:52:32	14:52:53	0:00:21	1	Blue Whale	4	Flukes up and dove	BW

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_27_SES_Video_145601-145825_ID01_Blue	7/27/2010	14:56:01	14:58:25	0:02:24	1	Blue Whale	4	1 indiv., below surface, multiple blows, slow travel,	BW
SOCAL_2010July_27_SES_Video_150525-150654_ID01_Blue	7/27/2010	15:05:25	15:06:54	0:01:29	1	Blue Whale	4	1 indiv., resting below surface, multiple blows	BW
SOCAL_2010July_27_SES_Video_150939-151242_IDX01_Blue	7/27/2010	15:09:39	15:12:42	0:03:03	1	Blue Whale	4	multiple blows, 1 indiv., shallow dive, slow travel,	BW
SOCAL_2010July_27_SES_Video_152454-152516_ID05_Blue	7/27/2010	15:24:54	15:25:16	0:00:22	5	Blue Whale	6	1 indiv, subsurface, blows, arched back then flukes up and dives	BW
SOCAL_2010July_27_SES_Video_152550-152832_IDX05_Blue	7/27/2010	15:25:50	15:28:32	0:02:42	5	Blue Whale	6	whale scat, 2 indiv., slow travel, looks like mother calf pair	BW
SOCAL_2010July_27_SES_Video_153626-154427_ID05_Blue	7/27/2010	15:36:26	15:44:27	0:08:01	5	Blue Whale	6	2 indiv., swimming towards helicopter, whale #2 reorients to the right of whale #1, whale #2 is .5 body lengths behind #1, multiple blows, dispersal is now 2 body lengths, some white water when whales submerge, slow travel, whale #1 dove, whale #2 at surface then dives, both shallow dives, whale #2 now to the left of #1, poss #2 a calf, whales side by side .5 body lengths	BW
SOCAL_2010July_27_SES_Video_155012-155027_ID05_Blue	7/27/2010	15:50:12	15:50:27	0:00:15	5	Blue Whale	6	Flukes and dove	BW

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_27_SES_Video_155104-160113_ID05_Blue	7/27/2010	15:51:04	16:01:13	0:10:09	5	Blue Whale	6	2 indiv., second 2 body lengths behind to the right, slow travel, multiple blows, traveling away from helicopter, first whale circled around and 2nd whale dove, whale #2 up, swimming behind other whale 1.5 body lengths apart, whale #1 dove, whale #2 dove, whales surface together .5 body lengths apart side by side and it is a mother-calf pair, calf dove, mother subsurface, calf just below mother both under the surface, looks like they are floating just below surface, possible nursing, looks as if mother rolled to side	BW
SOCAL_2010July_27_SES_Video_160446-160832_ID05_Blue	7/27/2010	16:04:46	16:08:32	0:03:46	5	Blue Whale	6	1 indiv. , 3 spots of scat, multiple blows, slow travel, arched back, flukes up and dove	BW
SOCAL_2010July_27_SES_Video_161013-161217_ID05_Blue	7/27/2010	16:10:13	16:12:17	0:02:04	5	Blue Whale	6	2 indiv., multiple blows, slow travel, front animal 4 body lengths apart, not 2 body lengths apart, the 2nd is behind to the left,	BW

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_27_SES_Video_161740-162107_ID05_Blue	7/27/2010	16:17:40	16:21:07	0:03:27	5	Blue Whale	6	1 indiv. subsurface, looks as if it is floating just below surface, milling, whale turns slightly on its side, arched back and dove	BW
SOCAL_2010July_27_SES_Video_162117-162127_IDXX_Unid	7/27/2010	16:21:17	16:21:27	0:00:10	XX	Unidentified Whale Scat		Whale scat	BW
SOCAL_2010July_27_SES_Video_162141-162147_IDXX_Unid	7/27/2010	16:21:41	16:21:47	0:00:06	XX	Unidentified Whale Scat		Big blob of whale scat	BW
SOCAL_2010July_28_SES_Video_134711-135024_ID02_Blue	7/28/2010	13:47:11	13:50:24	0:03:13	2	Blue Whale	3	cannot hear vocals, multiple blows, arched back and dove,	BW
SOCAL_2010July_28_SES_Video_135623-143050_ID02_Blue	7/28/2010	13:56:23	14:30:50	0:34:27	2	Blue Whale	3	Cannot hear vocals, 1 indiv. Subsurface, multiple blows, looks like it is logging, very slow travel, arched back and a fluke, dove, arched back and shallow dive, arched back and dove, flukes, seems to be floating at surface at times, arched back, flukes and dove	BW
SOCAL_2010July_28_SES_Video_145741-150356_ID08_Commonsp.	7/28/2010	14:57:41	15:03:56	0:06:15	8	Common Dolphin sp.	400	Surface active milling, dispersal 1-8, 1400 ft, angle 26, well over 100 animals, 2 groups, 1st group scattered	BW
SOCAL_2010July_28_SES_Video_152622-152628_IDBoat_Boat	7/28/2010	15:26:22	15:26:28	0:00:06	Boat	Boat	1	Private Boat Only	BW

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_28_SES_Video_154558-155422_ID13_Blue_Fin	7/28/2010	15:45:58	15:54:22	0:08:24	13	Blue Whale/Fin Whale	5 Blue 3Fin	oriented to 320, multiple blows, 3 indiv., slow travel, 3 fins, 2 blues, subsurface, blues oriented at 330, 3 animals are 1 body length apart, 3 fins and 3 blues, the fins are swimming towards a bait ball, one fin with mouth open	BW
SOCAL_2010July_29_SES_Video_143809-151936_ID01_Blue	7/29/2010	14:38:09	15:19:36	0:41:27	1	Blue Whale	2	2 indiv., slow travel, subsurface, multiple blows, lots of white water, vocals hard to understand, oriented at 180, angle 30 degrees, flukes, 2nd whale defecated, reoriented about 15 degrees to 210, about 1.5 body lengths apart	BW
SOCAL_2010July_29_SES_Video_155244-155545_ID02_Commonsp.	7/29/2010	15:52:44	15:55:45	0:03:01	2	Common Dolphin sp.	380	800 ft., looking at subgroup, orientation 270, unidentified splash, 2 gulls over dolphin	BW
SOCAL_2010July_29_SES_Video_155549-155744_ID02_Commonsp.	7/29/2010	15:55:49	15:57:44	0:01:55	2	Common Dolphin sp.	380	Dispersion 1-2	BW
SOCAL_2010July_29_SES_Video_160820-160905_ID03_Commonsp.	7/29/2010	16:08:20	16:09:05	0:00:45	3	Common Dolphin sp.	110	Bird association	BW
SOCAL_2010July_30_SES_Video_131258-151332_ID01_Risso's	7/30/2010	15:12:58	15:13:32	0:00:34	1	Risso's Dolphin	9	Oriented at 2 o'clock	BW

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_30_SES_Video_151558-152732_ID01_Risso's	7/30/2010	15:15:58	15:27:41	0:11:43	1	Risso's Dolphin	9	line abreast, dispersal 1-2, oriented at 330, dispersal now 1-5	BW
SOCAL_2010July_31_SES_Video_143756-155920_ID03_Blue	7/31/2010	14:37:56	14:59:20	0:21:24	3	Blue whale	6	.5 body lengths apart, 2 indiv	MS
SOCAL_2010July_31_SES_Video_14592-1529163_ID03_Blue	7/31/2010	14:59:23	15:29:16	0:29:53	3	Blue Whale	6	2 indiv.	MS
SOCAL_2010July_31_SES_Video_153608-153732_ID03_Blue	7/31/2010	15:36:08	15:37:32	0:01:24	3	Blue Whale	6	oriented at 300, 2 ind., one whale fluked and the second one sounded, angle is 26	MS
SOCAL_2010July_31_SES_Video_174437-175548_ID22_Blue	7/31/2010	17:44:37	17:55:48	0:11:11	22	Blue Whale	1		MS
SOCAL_2010July_31_SES_Video_175549-181939_ID22_Blue	7/31/2010	17:55:49	18:19:39	0:23:50	22	Blue Whale	1	oriented at 150	MS

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_2August_SES_Video_155827-163641_ID24_Blue	8/2/2010	15:58:27	16:36:41	0:38:14	24	Blue Whale	2	mother-calf pair, oriented at 210, calf rolled over, another adult blue whale 30 body lengths away, breaching, mother-calf .5 body lengths apart, calf now 5 body lengths apart from mother, calf breached, mother lunged and breached then sounded, calf breached and lunged 5 times, now mother-calf pair dove, 3 rd whale lunged twice, breached and blew, and fast travel, orientation now 300, calf lunged, angle from calf is 33 degrees, calf keeps lunging while mom underwater swimming	MS
SOCAL_2010July_2August_SES_Video_165955-175930_ID31_Blue	8/2/2010	16:59:55	17:59:30	0:59:35	31	Blue Whale	2	2 indiv., multiple blows, speed boat in picture but not close to whales, whale #2 defecated, #2 whale fluked then dove, 50 body lengths apart, oriented at 130, first whale angle 29 degrees, 2nd whale 37 degrees,	MS

Video Name	Date	Video Start Time	Video End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Grp Size Estim	Video Notes	Taken By
SOCAL_2010July_3August_SES_Video_173759-180230_ID41_Blue	8/3/2010	17:37:59	17:54:27	0:16:28	41	Blue Whale	2	pair of blue whales surfaced, multiple blows, some glare, whales sounding, fluke up dive on whale #1, dispersal is one body length apart, gulls overhead, dolphins seen in water concentration on blue whale focal, 550 ft., fluke up again on whale #1, plane had to go low to get out of way of F16's, possible fin, blues surfaces, fast travel, sounded, whale #1 arch back and dive,	MS
SOCAL_2010July_3August_SES_Video_175429-180230_ID41_Blue	8/3/2010	17:54:29	18:02:30	0:08:01	41	Blue Whale	2	One whale seen, blow, fluke up, poss fin whale seen in beginning of video, 2 blues seen again from previous video, multiple blows by each blues, video camera put down for photos, 2000 ft.	MS

Table D-2. Videos recorded during September SOCAL 2010 aerial monitoring surveys off San Diego, California, based on preliminary review of video.

Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Approx. Group Size	Video Notes	Taken By
SOCAL_2010Sept_23_SES_Video_161914-162115_ID06_CommonDolphinSp.	9/23/2010	16:19:14	16:21:15	0:02:01	6	Common Dolphin sp.	60	No voice on video, bird association	MS
SOCAL_2010Sept_23_SES_Video_162118-162244_ID06_CommonDolphinSp.	9/23/2010	16:21:18	16:22:44	0:01:26	6	Common Dolphin sp.	60	No voice on video, bird association, animals spread out, inverted lunge	MS
SOCAL_2010Sept_23_SES_Video_162252-162416_ID06_CommonDolphinSp.	9/23/2010	16:22:52	16:24:16	0:01:24	6	Common Dolphin sp.	60	No voice on video, bird association, inverted lunge	MS
SOCAL_2010Sept_23_SES_Video_162418-162429_ID06_CommonDolphinSp.	9/23/2010	16:24:18	16:24:29	0:00:11	6	Common Dolphin sp.	60	No voice on video, 1 individual	MS
SOCAL_2010Sept_26_SES_Video_122055-122128_IDBoat_Boat	9/26/2010	12:20:55	12:21:28	0:00:33	Boat	Boat	1		BW
SOCAL_2010Sept_26_SES_Video_122421-122439_IDBoat_Boat	9/26/2010	12:24:21	12:24:39	0:00:18	Boat	Boat	1	R/V Robert Gordon Sproul	BW
SOCAL_2010Sept_26_SES_Video_122955-123021_IDBoat_Boat	9/26/2010	12:29:55	12:30:21	0:00:26	Boat	Boat	1	R/V Robert Gordon Sproul	BW

Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Approx. Group Size	Video Notes	Taken By
SOCAL_2010Sept_26_SES_Video_131518-133022_ID15_CommonDolphinSp.	9/26/2010	13:15:18	13:30:22	0:15:04	15	Common Dolphin sp.	1000	voice hard to understand, 1000 to 1200 individuals, bird association, dispersion 1-2, oriented at 090, group is more longer than horizontal, dispersion is 1-5, slow travel, no behavior changes seen	BW
SOCAL_2010Sept_26_SES_Video_133347-133845_ID15_CommonDolphinSp.	9/26/2010	13:33:47	13:38:45	0:04:58	15	Common Dolphin sp.	1000	Same group as above, oriented at 090, dispersion 1-2, slow surface active travel, bird association, group in a slight triangle shape, oriented at 080, shape is a rectangle, dispersion 1-3, birds circling above dolphin	BW
SOCAL_2010Sept_26_SES_Video_165617-165811_ID31_CommonDolphinSp.	9/26/2010	16:56:17	16:58:11	0:01:54	31	Common Dolphin sp.	400	Animals all spread out, 80-100 individuals, calf seen,	BW

Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Approx. Group Size	Video Notes	Taken By
SOCAL_2010Sept_26_SES_Video_165819-171548_ID31_CommonDolphinSp.	9/26/2010	16:58:19	17:15:48	0:17:29	31	Common Dolphin sp.	400	Animals spread out, bird association, foraging, inverted swimming, 12 subgroups, surface active milling with birds, occasional lunging, spacing 1-3, one subgroup has roughly 20 animals, spacing 1-2, traveling to 120, second subgroup- surface active milling, spacing 1-2, roughly 10 individuals, spacing 1-12, inverted swim, porpoise lunging with birds, spacing 1-15, split up into 3 groups of 5, inverted swim, sighting number 30, spacing 1-18, 3rd subgroup- surface active milling, spinning, turning, spacing is 1-2, 5 animals in subgroup, inverting swim, lunging, porpoising, still surface active swim, birds swoop down with dolphin come to surface	BW
SOCAL_2010Sept_27_SES_Video_105235-105354_ID16_Risso's	9/27/2010	10:52:35	10:53:54	0:01:19	16	Risso's Dolphin	30	oriented 220, spacing 1-18, one animal is 30 body lengths, another animal 60 body lengths, 17 animals, slow travel,	BW

Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Approx. Group Size	Video Notes	Taken By
SOCAL_2010Sept_27_SES_Video_105413-110843_ID16_Risso's	9/27/2010	10:54:13	11:08:43	0:14:30	16	Risso's Dolphin	30	spacing is 1-15, group really spread out, few animals 100 body lengths away, slow travel, foraging, bird flying by, 2 subgroups, 19 individuals, oriented at 220, line abreast formation, slow travel, 3 animals tightly grouped, in group spacing 1-2, otherwise 15-100 body lengths apart, animals not changing behavior, animals seem to be all coming together, animals turned to the west, spacing 1-3, slow travel, possible calf	BW
SOCAL_2010Sept_27_SES_Video_122343-124044_ID36_Risso's	9/27/2010	12:23:43	12:40:44	0:17:01	36	Risso's Dolphin	8	group of 2 trailing, with a group of 6-7 in the front, orientation 330, spacing 1-8, below surface, very tight in the front group, slow travel, 8 body lengths, orienting towards each other, spacing 1-4, oriented at 230, one animal in lead 100 body lengths away, logging, line abreast at surface, slow travel, spacing 1-7, most of group headed towards 230, resting at surface, spacing 1-1 in subgroup	BW

Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Approx. Group Size	Video Notes	Taken By
SOCAL_2010Sept_27_SES_Video_150429-151406_ID61_CommonDolphinSp.	9/27/2010	15:04:29	15:14:06	0:09:37	61	Common Dolphin sp.	135	birds on water, 1000 ft., foraging, dispersal within subgroup is 1-2, dolphin going in 2's and 3's chasing the birds, inverted swim, lunge and then dive	BW
SOCAL_2010Sept_27_SES_Video_153115-155635_ID65_CommonDolphinSp.	9/27/2010	15:31:15	15:56:35	0:25:20	65	Common Dolphin sp.	70	inverted swim, lunging, huge group of dolphin, roughly 1200 individuals, surface active travel, v shaped formation, orientation 350, fast travel, 1-2 spacing, boat 40 vessel lengths behind dolphins, group in front has 20 dolphins, oriented at 350, fast travel, spacing 1-2 for group in front, oblong formation, wider than long	BW
SOCAL_2010Sept_28_SES_Video_125907-130846_ID12_CommonDolphinSp.	9/28/2010	12:59:07	13:08:46	0:09:39	12	Common Dolphin sp.	400	bird association, two animals lunging together, spacing 1-2, 4-5 subgroups, milling with birds, 3 animals inverted lunge, multiple splashes, swimming inverted, competing for food, spacing 1-3, 2 inverted, one lunge turn, birds on water, split into 2 subgroups	BW

Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Approx. Group Size	Video Notes	Taken By
SOCAL_2010Sept_28_SES_Video_132405-134500_ID15_Risso's	9/28/2010	13:24:05	13:45:00	0:20:55	15	Risso's Dolphin	25	blow, blow, one animal, blow, heading is 7 o'clock, sub-surface, blow, traveling, heading towards 5 0'clock, slow travel below surface	BW

Appendix E. Photo Log

Table E-1. List of Photographs Taken during the 27 July - 3 August 2010 Navy SOCAL Aerial Survey off San Diego, California.

Date 2010	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
27-Jul	1	Blue whale	4	5	196	142	14:09	15:06
27-Jul	2	Bottlenose dolphin	50	98	133	36	14:16	14:21
27-Jul	3	Fin whale	1	174	187	14	14:46	14:49
27-Jul	4	Common dolphin sp.	400	204	220	17	15:32	15:33
28-Jul	2	Blue whale	6	2	190	190	13:47	14:28
28-Jul	8	Common dolphin sp.	400	194	228	25	14:56	15:01
28-Jul	13	Blue/Fin whale	5/3	231	306	76	15:46	15:55
29-Jul	1	Blue whale	2	314	404	91	14:49	15:39
29-Jul	7	Blue whale	3	405	461	57	16:24	16:29
31-Jul	2	Common dolphin sp.	100	545	563	19	15:04	15:04
31-Jul	3	Blue whale	6	567	761	195	15:05	15:31
31-Jul	5	Common dolphin sp.	200	765	798	34	15:52	15:54
31-Jul	7	Common dolphin sp.	60	801	868	68	16:10	16:14
31-Jul	9	Unidentified dolphin	25	873	888	15	16:24	16:29
31-Jul	14	Common dolphin sp.	120	889	940	52	16:48	16:51
31-Jul	17	Common dolphin sp.	15	943	952	10	17:24	17:26
31-Jul	19	Common dolphin sp.	125	955	1003	49	17:34	17:36
31-Jul	22	Blue whale	1	1006	1321	310	17:53	18:13
2-Aug	2	Blue whale	2	1324	1347	24	16:57	16:59
2-Aug	8	Blue whale	2	1355	1434	80	17:57	18:27
2-Aug	10	Common dolphin sp.	55	1437	1454	18	18:50	18:50
2-Aug	11	Common dolphin sp.	125	1457	1508	52	18:53	18:55
2-Aug	12	Blue whale	2	1511	1826	302	18:56	17:28
3-Aug	7	Common dolphin sp.	1000	1657	1734	78	15:46	15:48
3-Aug	8	Common dolphin sp.		1736	1798	63	15:52	15:53
3-Aug	11	Common dolphin sp.	100	1800	1833	34	15:58	15:58
3-Aug	12	Common dolphin sp.		1835	1900	66	15:59	16:08
3-Aug	20	Common dolphin sp.	300	1902	1976	75	16:24	16:26
3-Aug	29	Common dolphin sp.	140	2003	2042	40	17:04	17:05
3-Aug	36	Common dolphin sp.	7	2044	2069	26	17:14	17:16
3-Aug	40	Blue whale	1	2076	2078	3	17:33	17:34
3-Aug	41	Blue whale	2	2080	2107	28	17:34	17:34
3-Aug	39	Common dolphin sp.	120	2109	2123	15	17:39	17:41
3-Aug	41	Blue whale	2	2125	2170	46	17:42	17:43
3-Aug	39	Common dolphin sp.	120	2171	2189	19	17:44	17:47
3-Aug	41	Blue whale	2	2190	2228	39	17:48	17:51
3-Aug	41	Blue whale	2	2230	2249	20	17:54	17:54
3-Aug	41	Blue whale	2	2251	2262	12	17:55	17:56

Table E-2. List of Photos taken during the 23 - 28 September 2010 Navy SOCAL Aerial Survey off San Diego, California.

Date 2010	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
23-Sep	1	Common dolphin sp.	25	1	34	34	15:14	15:16
23-Sep	2	Common dolphin sp.	6	37	63	27	15:32	15:33
23-Sep	3	Unidentified marine mammal	1	67	111	45	15:55	15:57
23-Sep	4	Common dolphin sp.	15	114	144	31	16:09	16:10
23-Sep	6	Common dolphin sp.	60	147	211	65	16:17	16:19
24-Sep	7	Common dolphin sp.	700	1796	1811	16	12:30	12:32
24-Sep	23	Unidentified marine mammal	1	1812	1818	7	12:56	12:57
24-Sep	46	Bryde's whale	1	1819	1829	5	13:44	13:44
24-Sep	55	Common dolphin sp.	250	1832	1845	12	14:18	14:21
24-Sep	56	Unidentified dolphin	1	1849	1856	5	14:24	14:28
24-Sep	69-72	Common dolphin sp.	530	1857	1872	12	16:17	16:59
24-Sep	73	Common dolphin sp.	40	1871	1882	11	16:59	17:05
24-Sep	75	Common dolphin sp.	300	1884	1889	6	17:10	17:13
24-Sep	77	Common dolphin sp.	9	1890	1895	6	17:16	17:16
25-Sep	7	Common dolphin sp.	1100	1917	1920	4	11:08	11:12
25-Sep	8	Common dolphin sp.	400	54	60	6	11:09	11:11
25-Sep	11	Common dolphin sp.	100	1921	1929	9	11:41	11:43
25-Sep	11	Common dolphin sp.	100	61	64	4	11:41	11:43
25-Sep	12	Common dolphin sp.	400	1930	1932	3	11:48	11:49
25-Sep	13	Northern elephant seal	11	65	72	8	11:56	11:58
25-Sep	15	California sea lion	35	1938	1943	6	12:18	12:20
25-Sep	18	Common dolphin sp.	1600	78	87	10	12:43	12:44
25-Sep	19	Common dolphin sp.	150	89	92	4	12:53	12:53
25-Sep	19	Common dolphin sp.	150	1944	1955	12	12:54	12:58
25-Sep	21	Unidentified dolphin	50	1956	1966	11	13:03	13:06
25-Sep	23	Common dolphin sp.	75	1968	1972	5	13:23	13:25
25-Sep	24	Common dolphin sp.	200	94	98	5	13:24	13:24
26-Sep	15	Common dolphin sp.	1000	1987	2015	29	13:14	13:40
26-Sep	28	Common dolphin sp.	450	2021	2038	18	16:03	16:10
27-Sep	16	Risso's dolphin	5	1	6	6	10:50	11:56
27-Sep	29	Minke whale	1	7	19	13	11:56	11:57
27-Sep	58	Common dolphin sp.	275	28	34	7	14:58	15:00
27-Sep	64	Common dolphin sp.	1299	36	46	11	15:29	15:30
28-Sep	3	Common dolphin sp.	600	11	66	56	9:25	9:29
28-Sep	5	Sei/Bryde's whale	3	68	126	59	9:56	9:58
28-Sep	12	Common dolphin sp.	400	130	210	71	13:10	13:12
28-Sep	23	Bottlenose dolphin	18	215	246	31	14:23	14:30

Appendix F. Photos

Aerial photographs of cetaceans using a telephoto lens from the aircraft during the July and September 2010 SOCAL aerial survey monitoring effort off San Diego, California, under NMFS Permit 15369.

Photo 1. Blue whale photographed 2 August 2010 by M.A. Smultea under NMFS Permit 15369.

Photo 2: Sei/Bryde's whales photographed 28 September 2010 by B. Würsig under NMFS Permit 15369.

Photo 3: Bryde's whale photographed 24 September 2010 by B. Würsig under NMFS Permit 15369.

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AERIAL SURVEYS CONDUCTED IN THE SOCAL OPAREA FROM 01 AUGUST 2010 TO 31 JULY 2011

Prepared for
Commander, Pacific Fleet, Pearl Harbor, Hawaii

Submitted to
Naval Facilities Engineering Command Southwest (NAVFAC SW), EV5 Environmental Planning, San Diego, CA, 92132

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Prepared by

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HDR Inc.
San Diego, California

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Cover Photo: Blue whale (*Balaenoptera musculus*), photographed with a telephoto lens from the Partenavia fixed-wing aircraft during a winter 2011 SOCAL aerial monitoring survey. Photo by B. Würsig under NMFS permit 14451.

INTRODUCTION

This report summarizes all five aerial surveys conducted between 31 August 2010 and 31 July 2011 on the Navy's Southern California Range Complex (SOCAL) to monitor marine mammals in conjunction with or separate from Major Training Exercises (MTEs), as described in the Scopes of Work (SOW). The overall goal per the SOW was to complete approximately 169 hours of aerial survey effort during the fall and winter, weather permitting, which was as behaviorally focused as possible (previous monitoring surveys since 2008 have occurred in spring, summer, and fall). In particular, the SOW for the May aerial survey provided additional funding to conduct preliminary summary analyses of behavioral data. Behavioral data provide baseline information to assess potential changes in behavior (or lack thereof) relative to various received sound levels from mid-frequency active sonar and other MTE activities. Collection of baseline behavioral data is a goal identified in the Navy's SOCAL Marine Species Monitoring Plan (SMSMP) (DoN 2009).

Three surveys were scheduled to occur before, during, and/or after MTEs, while the remaining two surveys were specifically scheduled when no MTEs were occurring: the September 2010 survey occurred during and after MTEs; the February 2011 survey occurred before, during, and, after MTEs; the March and April 2011 surveys did not overlap with any MTEs; and the May 2011 survey occurred during an MTE. The March and April scheduling facilitated (1) more frequent access to the Southern California Anti-Submarine Warfare Range (SOAR), which is limited during MTEs, and (2) collection of baseline data on the cool-water period and behavior of marine mammals on the SOCAL Range.

Surveys occurred in the Northern Air Operating Area (NAOPA) and SOAR. In April and May, systematic survey lines were flown for the first time near Silver Strand and in San Diego Bay, just south of Point Loma.

Methods

Methods generally followed protocols implemented during aerial survey monitoring efforts conducted in SOCAL during seven previous surveys (e.g., Smultea & Lomac-MacNair 2010; Smultea et al. 2011a,b,c,d). Effort was divided into "on effort" (at least one observer searching for animals) and "off effort" (no observers searching; e.g., while flying over land, or while clouds obscured viewing). On effort was further divided into line-transect, connectors (i.e., short lines connecting systematic transect lines), transit, random, and circling modes (either focal follow or "identify" modes) (see Smultea et al. 2009a,b and Smultea & Lomac-MacNair 2010 for full definitions). The primary exceptions to past survey protocols are as follows.

1. Search effort was focused in areas where priority species (blue, fin, and beaked whales) were expected to occur (based on results of previous surveys) to maximize time conducting focal behavioral follows. Such areas included steep underwater drop-offs/ridges (particularly just west of San Clemente Island and about 40 kilometers [km] (22 nautical miles [nm]) west of San Diego), and an approximately 100-square-km (km2) area about 5 to 10 km (3 to 5.5 nm) offshore of San Diego where blue and fin whales have tended to concentrate.

2. The September 2010 survey was conducted on behalf of the Navy by Smultea Environmental Sciences (SES) under contract to Scripps' Institute of Oceanography. The remaining four surveys were conducted by HDR, Inc.

3. In September 2010, one pilot and three biologists (two observers and one recorder) flew the survey; the recorder sat in the co-pilot seat and took photos and video through the only opening port in a window in the Partenavia. This opening was a flip-up circular window approximately 10 cm (4 inches) in diameter at the right front seat. During the four subsequent 2011 surveys two pilots flew the plane as required under the indefinite delivery/indefinite quantity (IDIQ) contract to HDR; thus, the two observers sat in the middle seats and the recorder sat in the rear seat.

4. The September 2010 aerial survey was flown from a high-wing, fixed-wing, twin-engine Partenavia P68-OBS Observer airplane (tail number N6602L) with a glass nose. The February, March, and May surveys were flown from a Partenavia P68-C airplane model that did not have a glass nose. In April, a high-wing fixed-wing, twin-engine Twin Commander 685 aircraft was used for the first time to conduct aerial survey monitoring under the SMSMP. The aircraft holds up to eight observers; however, only two pilots and three observers/recorders sat in the plane for the survey (the recorder sat in the rear bench seat).

5. The Twin Commander model used had only one approximately 13-by-13 centimeter (5-by-5-inch) port opening in the left front pilot's window. Therefore, the professional observers could only take photographs and video through closed, double-paned Plexiglas windows. These windows distorted images and decreased the resolution such that photographs and video could not be used to differentiate some species, particularly long-beaked vs. short-beaked common dolphins. The degraded quality of photographs through the closed windows where the observers sat necessitated that the pilot sitting in the left front seat, who was not an experienced photographer, take species identification photos (the other pilot flew the plane when this occurred). The latter photos were of limited utility.

6. Video taken through the Twin Commander's closed windows could be used to track gross behaviors and relative positions of whales and, to some extent, Risso's dolphins due to their light body coloration. However, such video was not useful for tracking behavior of small dolphins or for tracking detailed behaviors such as social/touching interactions.

7. The Twin Commander did not have bubble windows. Its small flat windows curtailed the ability to see directly under the plane (maximum declination angle around 60 degrees vs. 90 degrees with the bubble window). The ability to see directly under the plane is an important assumption in line-transect theory.

8. The Twin Commander had a longer range than the Partenavia: the maximum length of each flight was about 6 hours vs. 3.5 hours in the Partenavia.

9. Line-transect surveys in the Twin Commander were flown at 120 to 125 knots (kts) (it could not safely fly any slower) vs. approximately 100 kts in the Partenavia. Circling was also conducted at 120 to125 kts vs. 85 to 90 kts in the Partenavia. The faster circling speed of the Twin Commander made it more difficult to keep sightings in view while photographing and videotaping vs. the slower-circling Partenavia.

10. The marine species observers' windows were smaller in the Twin Commander than the Partenavia. Thus, it was difficult for the designated focal-behavior observer to see and call

behaviors because the video recorder blocked the view through one window, and the view was blocked by the cowling in the rear windows. In contrast, in the Partenavia, the recorder sat in the rear bench seat where the only opening window was located; the focal observer sat in the center seat with a different window on the same side of the plane, but in front of the video recorder, and looked through a large bubble window.

11. In April and May, systematic survey lines were flown for the first time near Silver Strand. The eight transect lines extended 40 km (22 nm) west of Silver Strand and also included portions of San Diego Bay. The bay was surveyed to search for sea turtles. Transect lines were spaced 1.9 km (1 nm) apart during marginal weather conditions and 3.7 km (2 nm) apart at other times, to maximize the ability to see marine mammals.
12. In February and March, bubble windows at the center seats of the Partenavia were replaced with flat Plexiglas with an approximate 15-by-20-cm (6-by-8-inch) opening "flap" window suitable to allow photography and video without the distortion created by Plexiglas bubble windows. This occurred because, for the first time during the SOCAL surveys, two pilots were required per the Navy IDIQ awarded in 2010 to HDR, Inc. As a consequence:
    a. One marine species observer (MSO) could no longer sit in the co-pilot seat and take photos through a small opening port in the front, right, flat window. Due to structural limitations, an opening port could not be constructed within the bubble window to allow undistorted photography/video. Consequently, the flat window with an opening port was installed. A limitation of this approach was that the engine cowling obstructed the MSO's view during sharply banked turns, resulting in missed video and photo opportunities. This had not been an issue from the front co-pilot seat during previous surveys.
    b. The flat window curtailed the ability to see directly under the plane (maximum declination angle 63 degrees vs. 90 degrees with the bubble window). The ability to see directly under the plane is an important assumption in line-transect theory.
13. In May, the port-opening window of the Partenavia was placed in the left rear window and the bubble windows were replaced in the center seats. This proved to be a better position from which to take photos and video, as the cowling was less of a visual obstruction. However, exhaust fumes occasionally blurred the view.
14. Instead of a small, digital, hand-held voice recorder connected to a spare audio jack in the aircraft, a voice-activated, mini-microphone was taped into the headphone of one observer to record all audio on the plane. The previous recording method resulted in frequent noise interference from the aircraft despite the use of impedance cables, rendering recordings indiscernible on some occasions. The new method appeared to work better. However, when the mini-microphone was placed inside the headphone of the photographer, wind noise from the port window opened for photography/video interfered with the ability to hear the recorded audio. Recordings improved when placed inside the headphone of a non-photographer/videographer who did not open a nearby window; this much-reduced the wind noise interference.
15. In September, February, March, and April, a small PC laptop Acer computer was used to collect sighting, effort, and behavioral data with a custom-designed Excel spreadsheet with newly implemented "hot buttons" that automatically time-stamped entries. Ease of

data entry is critical due to the speed and volume of data streaming in and being recorded during the high-density SOCAL surveys. This format has been refined and tested over multiple surveys.

16. In April and May, the Mysticetus Observation Platform software, created by Entiat River Technologies, was Beta-tested during aerial surveys, at no expense, in order to provide feedback on software improvement. This program proved to be the "best fit" of any previously used aerial software based on the following features:
    a. Mysticetus provided real-time distance and bearing to a sighting by synthesizing real-time Global Positioning System (GPS) data with the declination angles (converted to distance) and times of sightings. This feature was critical in helping the pilots to relocate sightings quickly, even in higher Beaufort conditions when sightings are typically challenging to re-find. Relative location of the sighting to the aircraft was continuously displayed on the laptop screen, and adapted to changing distances and headings of the aircraft. The recorder communicated to the pilots how to adjust the flight pattern to relocate the sighting.
    b. Field data entries were expedited by alias lists (e.g., auto-fill features) and other shortcuts. This improved the ability to collect data in high-volume observation conditions.
    c. Post-survey analysis tools, including automated on-effort survey reports (e.g., total hours and kilometers of effort by date, total sightings by species, etc.), and Google Earth 3-D track display, were beta-tested for the potential to reduce data post-processing requirements. However, because both previous software and Mysticetus were used on different days due to the beta-testing process, this feature could not be universally applied to the data.
    d. Previously, the GPS data have been collected separately and subsequently merged with field data via Excel. This step is not necessary with Mysticetus, which merges GPS data in real-time with sightings, behavior, and environmental data. However, both processes were used during the survey due to the beta-testing phase (see paragraph above).
17. Ocean sunfish (*Mola mola*) counts and declination angles started being recorded during the March survey. The first counts were recorded on 1 April 2011, which was the last day of the March survey. This was done in response to communications with Navy personnel indicating that there was a desire to collect information on other large marine species observable from the aircraft. Ocean sunfish sightings are not included in the overall sighting counts for marine mammals reported under the Results section.
18. Guardian mobility satellite tracking— a satellite tracking device for Aspen Helicopters for tracking the airplane was used while the airplane was in the air. We had a team member on shore following our tracklines on the internet (e.g., when we had staff working onshore while we flew); Aspen Helicopters office staff also tracked the plane while it was flying.

Results

The following subsections briefly summarize results for the five aerial surveys conducted in September 2010 and February, March, April, and May 2011. Detailed summaries for each survey are presented in tables and figures (maps) in separate appendices as follows: Photos (**Appendix A**), Figures (**Appendix B**), and Tables (**Appendix C**).

23 September to 28 September. The September aerial survey was flown from a glass-nosed, fixed-wing, twin-engine Partenavia P68-OBS Observer airplane (tail identification number N6602L, www.aspenhelicopters.com). Effort occurred on all 6 scheduled survey days: 4 days in SOAR and 2 days in NAOPA. A total of 19.2 hours of flight time and 3918 km (2116 nm) of effort occurred between aircraft “wheels up” off the ground to “wheels down” when the plane landed (**Appendix C**). Observers were on-effort observing for about 96 percent of this time, with the remaining approximately 4 percent flown over land (**Appendix C**) (see Smultea & Lomac-MacNair 2010 for detailed protocol and definitions).

A total of 252 sightings of approximately 38,022 individual marine mammals comprising at least nine species were made on the 6 survey days in September (**Table 1**). The most frequently sighted species was the common dolphin (50% of all groups, 90% of all individuals), followed by the California sea lion (34% or 72 groups). The latter was a higher number of pinniped sightings than were made during any of the previous SOCAL aerial surveys conducted under the Navy’s marine mammal monitoring (see Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010, Smultea et al. 2010). Two species only seen once during previous aerial monitoring surveys were observed: the Bryde’s whale (one sighting) and Cuvier’s beaked whale (one sighting). Two species previously never or rarely seen during the SMSMP aerial surveys were observed: the sei/Bryde’s whale (one sighting) and northern elephant seal (three sightings). All four of the latter sightings were photo-documented, except the Cuvier’s beaked whale.

Sixteen focal behavioral follows occurred, each of at least 5 minutes duration: nine of common dolphins, three of Risso’s dolphins, one of a minke whale, one of sei/Bryde’s whale, one of California sea lions, and one of an unidentified baleen whale. A detailed focal session (including photographs) of three sei/Bryde’s whales occurred September 28 at 9:41 a.m. for about 43 minutes (**Table 2**). On 28 September, as we circled bottlenose dolphins near Santa Catalina Island, a tight group of California sea lions resting at the surface appeared to potentially react by changing their behavior during the third circling when the plane passed near them at about 70 degrees (379 meters). Some individuals made abrupt steep dives that created splashes.

14 February to 19 February. The February aerial survey was flown from a fixed-wing, twin-engine Partenavia P68-C (tail identification number N300LF, www.aspenhelicopters.com). This same model was used during past SOCAL aerial monitoring (e.g., Smultea et al. 2010). Effort occurred on 5 of the 6 scheduled survey days (**Appendix C**). No flight occurred on 19 February due to poor weather. Effort occurred in SOAR on 1 day, NAOPA on 4 days, and Silver Strand on 1 day. A total of 18 hours or 3,213 km (1,735 nm) of flight time from “wheels up” to “wheels down” was flown (**Appendix C**). Observers were on-effort observing for about 93 percent of this time, with the remaining approximately 7 percent flown over land or during poor weather (**Appendix C**).

A total of 83 sightings of approximately 11,131 individual marine mammals comprising at least nine species were made on the 5 February survey days (**Table 1**). The most frequently sighted species was the common dolphin (37% of all groups, 84% of all individuals), followed by the California sea lion (16% or 13 groups). Two species not seen during previous aerial monitoring surveys were observed: the eastern Pacific gray whale (five sightings) and Dall’s porpoise (one sighting). No photos were available for the Dall's porpoises due to the poor sea state, though two observers each saw them twice.

Eight focal behavioral follows, each of at least 5 minutes duration, occurred: three of Risso's dolphins, two of gray whales, two of common dolphin sp. and one of a fin whale. One of the Risso's dolphin sessions included systematic circling to assess behavior relative to various aircraft altitudes, as done on numerous other SOCAL surveys (SES, unpublished data). A detailed focal session of a gray whale mother with a very young (estimated age less than several days old) calf occurred February 15 at 8:45 a.m. for about 30 minutes (**Table 2**). Both photos and video recorded the session. Individual data on respiration and behavioral events and states were collected for this pair as they traveled slowly south during a Beaufort 1-2 off Point Loma. The calf appeared to be "riding" the mother with occasional nursing bouts. See **Table 2** and **Appendix D** for further details on this sighting. No apparently unusual behaviors were noted for any species.

29 March to 3 April. The March aerial survey was also flown from the Partenavia P68-C, N300LF. Effort occurred on 3 of the 6 scheduled survey days: 30 and 31 March and 1 April; no flights occurred on 29 March or 2-3 April due to plane maintenance issues (**Appendix C**). Effort occurred in SOAR on one day and in NAOPA on two days. A total of 9.5 hours or 1,865 km (1,007 nm) of flight time from "wheels up" to "wheels down" was flown (**Appendix C**). Observers were on effort for about 95 percent of this time; the remaining 5 percent of time was spent flying over land or during poor weather (**Appendix C**).

A total of 71 sightings of approximately 2,165 individual marine mammals comprising at least 10 species were made on the 3 March survey days (**Table 1**). As in February, the common dolphin was the most frequently sighted species (27% of all groups, 62% of all individuals). The second most frequently seen species was the Risso's dolphin (21% or 15 groups). Two species not seen during the February 2011 survey were observed: the northern right whale dolphin (four sightings) and humpback whale (one sighting). Fin whales and Dall's porpoises were absent during this survey, but were seen during February 2011. Two sightings of ocean sunfish were made during the March survey; these sightings are not included in the overall sighting counts for marine mammals.

Fourteen focal behavioral follows of at least 5 minutes each occurred: five with Risso's dolphins, four with common dolphins, two with northern right whale dolphins, two with single minke whales, and one with a gray whale mother-calf pair. One of the Risso's dolphin sessions included systematic circling to assess behavior relative to various aircraft altitudes (SES, unpublished data). During this detailed focal session, potential reaction behaviors (clumping and going below the surface) were seen and might have been associated with an approximate 50 ft vessel passing within about 720 m (2,500 ft) of the Risso's group. A minke whale and 15 common dolphins were seen during the middle of this focal session.

On 1 April, Risso's dolphins were seen in close association with northern right whale dolphins on SOAR in Beaufort sea state 2 (**Appendix B**). Video and photographs were taken. This species association had not been previously observed during other SOCAL monitoring surveys. The Risso's dolphins appeared to be foraging. They were spread out with large inter-individual dispersal distances, with occasional "sprinting" that created white water, followed by a sudden dive, presumably to chase prey. The northern right whale dolphins were intermingled with the Risso's dolphins on several occasions.

12 April to 20 April. The April survey was flown using the Twin Commander 685, N9199N aircraft. Effort occurred on all nine of the scheduled survey days (**Appendix C**). Effort occurred in SOAR on two days, NAOPA on six days and in Silver Strand on two days. A total of 46.1 hours or 10,893 km (5,882 nm) of flight effort from "wheels up" to "wheels down" was flown (**Appendix C**). About 9.3 hours or 2,363 km (1276 nm) of this effort occurred in Silver Strand, and 0.4 hour or 102 km (55 nm) occurred within San Diego Bay. Observers were on watch for about 95 percent of the total 44.2 hours of flight effort, with the remaining 5 percent flown over land, or during poor weather (**Appendix C**). The weather was poor (marine fog layer) 18–20 April, which delayed our ability to do focal sessions (**Appendix C**).

A total of 136 sightings of approximately 14,130 individual marine mammals comprising at least 12 species was made over the 9 survey days (this includes Silver Strand—see next paragraph) (**Table 1**). Again, the most frequently sighted species was the common dolphin (33% of all groups, 86% of all individuals) followed by the Risso's dolphin (21% or 28 groups). A total of 44 sightings of ocean sunfish occurred during the April survey. These sightings are not included in the overall sighting counts for marine mammals.

Of the total 136 sightings, 21 sightings of approximately 2,177 individual marine mammals were seen within the Silver Strand survey area (**Appendix C**). Most sightings were seen more than 16 km (10 nm) offshore from Silver Strand. The latter total included eight common dolphin groups; three blue whales; three unidentified dolphin groups; two bottlenose dolphin groups; and one sighting each of Risso's dolphins fin, and humpback whales. **Appendix C** includes all April sightings in Silver Strand and provides their GPS locations.

Fifteen focal behavioral follows of at least 5 minutes each occurred: six with Risso's dolphins, four with fin whales, two with common dolphins, one with a gray whale mother-calf pair, one with Dall's porpoise, and one with a blue whale. Dall's porpoises were circled by the aircraft on 13 April at 3:23 p.m. for about 17 minutes. The three small porpoises exhibited the unique "rooster tailing" of this species during fast travel. A detailed focal session on a gray whale mother with a calf occurred April at 12:55 p.m. for about 15 minutes; video was taken of this pair. Individual respiration data and behavioral events and states were collected for the pair as they traveled slowly south during a Beaufort 2. The calf interacted with the mother and swam on top of her. The calf appeared to nurse on several occasions based on its position relative to the mother's peduncle area as it remained stationary at an angular position below the mother. The calf moved under the mother's tail flukes from one side to the other in an apparent effort to return to a nursing position on the opposite side of the mother. See **Table 2** and **Appendix D** for detailed information about this sighting.

9 May to 14 May. The May survey was flown from the same Partenavia P68-C (N300LF) airplane as the February and March surveys (**Appendix C**). Effort occurred on all 6 of the scheduled survey days: 1 day at SOAR and Silver Strand, 4 days at NAOPA, and 1 day at Silver Strand and NAOPA (**Appendix C**). A total of 27 hours or 4,896 km (2,642 nm) of flight time from "wheels up" to "wheels down" was flown (**Appendix C**). Observers were on-effort observing for about 94 percent of this time, with the remaining 6 percent spent flying over land or during poor weather (**Appendix C**).

A total of 81 sightings of approximately 3,309 individual marine mammals comprising at least 11 species were made over the 6 survey days (**Table 1**). Unlike previous surveys, three species were similar in terms of proportion and number of sightings: the common dolphin (16% or 13 groups), California sea lion (16 percent or 13 groups), and blue whale (15% or 12 groups) (**Table 3**). Again, by far the most frequently sighted species in terms of individuals was the common dolphin (73% of all individuals). However, there were twice as many individual fin whales seen (n = 30) than blue whales (n = 15) (**Table 3**). Three blue whales were consistently seen feeding about 19 km (10 nm) off San Diego. No gray whale or Dall's porpoise sightings were identified, in contrast to prior 2011 surveys. A dead humpback whale was seen on May 10 and 11 (**Table 2**); these two sightings were presumed to be the same animal based on examination of photos of the underside of the tail flukes. A blue shark (*Prionace glauca*) about 3 meters (9.8 feet) long was seen circling the dead whale on 11 May. On 10 May, the whale was seen about 7 km (4 nm) west of Soledad, San Diego, and no sharks were seen. During May, efforts were concentrated along underwater ridges where anticipated concentrations of species were to occur, especially fin whale and Risso's dolphin. On 9 May, a 10-meter (33-foot) whale shark was seen while circling a blue whale (33.255 N, 117.548 W).

For the first time since SOCAL aerial monitoring surveys began in fall 2008, sperm whales were seen (a group of 20 including 4 calves). They were associated with both Risso's and northern right whale dolphins. The sighting occurred on 14 May approximately 44 km (24 nm) west of San Diego near the edge of an underwater ridge (**Table 2**). A total of 14 sightings of ocean sunfish was made during the May survey.

Eighteen focal behavioral follows occurred of at least 5 minutes each: six with fin whales; five with Risso's dolphins; four with blue whales; and one each with sperm whales, Risso's dolphins, and northern right whale dolphins (the latter three in the same multi-species association). On 14 May at 10:36 a.m., a detailed focal session on 20 sperm whales (including 4 calves), northern right whale dolphins, and Risso's dolphins occurred (**Table 2**). Videos and photos were taken during the 67-minute focal session. One sperm whale calf was seen very close to the mother while Risso's dolphins were seen swimming with and harassing the sperm whale nursery group.

On numerous occasions, sperm whales were seen opening their mouths and dropping their lower jaws, only when a Risso's dolphin swam close by (**Appendices A** and **B**).

MAY 2011 AERIAL SURVEY BEHAVIORAL ANALYSIS

This report presents the summary analyses and descriptive statistics conducted for the May 9-14, 2011 SOCAL aerial survey. The SOW for the May survey was the only one of 12 aerial surveys conducted in SOCAL since 2008 that directed and funded summary analyses of behavioral data within the survey SOW. Summary statistics were performed for variables identified as potential quantitative indicators of stress or changes in behavior relative to stimuli, based on previous studies of different or similar species (e.g., summarized in Richardson et al. 1985a,b, 1995; also see Würsig et al. 1985, 1986, 1989; Vaughn et al. 2010). Variables were identified and summarized in Smultea et al. (2009a,b; **Appendix B** of the monitoring report). These included (1) minimum and maximum dispersal distance between nearest individuals within a subgroup (see Smultea et al. 2011 for behavioral ethogram); (2) behavior state; (3) heading; (4) behavioral event frequencies; and (5) respiration, dive, and surface-duration rates as applicable. Per the SOW and HDR Work Plan, behavioral data were summarized as done in previous SOCAL aerial survey reports from 2008-2010 (e.g., Smultea et al. 2009a, b, Smultea and Lomac-MacNair 2010, Smultea et al. 2010).

Behavioral data were analyzed and summarized in the following formats: (1) a tabular list of focal groups and associated descriptors (**Appendix C, Table 16**); (2) an inventory list of video names, times, durations, subjects, and a brief content summary (**Appendix C, Table 14**); (3) a detailed transcription and integration of the times and behaviors recorded on video, and audio collected simultaneously with video, into a formatted Excel spreadsheet (unpublished data provided as a separate deliverable to the Navy); and (4) summary statistical analyses of selected variables identified above. Associated video data summary formats and protocols followed those developed and provided to the Navy by SES in spring 2011 (SES, unpublished data; Smultea et al., in prep.).

It is important to note that behavioral analyses conducted herein were limited to only one (May 2011) of the total 12 aerial surveys conducted in SOCAL from October 2008-May 2011 based on available funding. Thus, the largest sample size for any one species is too small to represent statistically meaningful analyses and interpretation. However, the SOW indicated that power analyses were desired for sighting rates calculated from the May 2011 aerial survey data. Power analyses are commonly used to estimate the minimum sample size needed to be reasonably likely to detect an effect within a given probability level, or to estimate the minimum effect size likely to be detected in a study based on a known sample size (e.g., at probability 0.05 or 0.01, etc.). A power analysis (or sensitivity test) is used to assess the probability that a statistical test will reject the null hypothesis when the null hypothesis is false (i.e., a Type II error). With increasing power/ sensitivity (generally but not always associated with a greater sample size), the probability of committing a Type II error (i.e., a false negative) decreases. The degree of sampling error in a data set is related to the sample size, i.e., the larger the sample the less potential for error in the resulting trends. Thus, general statistical principles recommend that the largest available database be used to conduct power analyses (Cohen 1988, Aberson 2010). A more robust behavioral analysis has recently been conducted by Smultea Environmental Sciences (SES) using much larger sample sizes collected during 8 of the total 12 SOCAL aerial surveys (see **Appendix B** of monitoring report). To provide more meaningful power analyses, utilization of data from the 12 surveys is recommended, to avoid the likelihood of analyzing a potentially misleading smaller database from only the May 2011 survey.

Similarly, conducting power analyses from the sighting rate (number of sightings per 1000 km of observation effort) estimated from only the May 2011 aerial survey is considered suboptimal.

Rather, abundance and density estimates conducted using DISTANCE software is the standard approach for addressing "sighting rates" (T. Jefferson, pers. comm.). Again, more reliable and robust sighting rates have been estimated using the latter approach based on eight SOCAL aerial surveys conducted in 2008-2010 (see **Appendix B** of monitoring report). Thus, given the small species sample sizes collected only during the May 2011 aerial survey, power analyses have not been conducted for these data based on resulting summary analyses and examination of the survey results. Again, this was to avoid the potential for misleading extrapolation and interpretation of data from only one survey, particularly given that data are now available from 12 SOCAL aerial surveys from 2008-2011. Upon discussion with Navy NTRs, DISTANCE analyses are planned to be conducted in the near future based on data from all 12 surveys. This analysis will provide a more reliable and appropriate sample size as recommended for power analysis statistics.

Methods

Data collection protocol, equipment, locations and time periods were already summarized in the May 2011 field summary report (Smultea and Bacon 2011) and are thus not discussed herein.

Two types of behavior analyses were conducted. The first involved the first observed behavioral variables recorded for all sightings using modified scan sampling. This total included all sightings whether or not they were circled for photographs or focal follows. This analysis is the same type conducted in previous SOCAL aerial survey reports (e.g., Smultea et al. 2009a,b, 2010a,b, 2011), as requested per the SOW. The second approach was limited to focal follows which consisted of extended observations from the aircraft while it circled overhead outside Snell's sound cone radius. Video was usually taken during focal sessions. See Smultea and Bacon (2011, **Appendix B** of monitoring report) for summaries of video and focals for the May 2011 aerial survey.

Results

Sighting Rates. Sighting rates (number of sightings per units of effort) of marine mammals during the May 2011 SOCAL aerial survey were estimated using a total of 49 sightings of 9 confirmed species (**Table 1**). Effort used to estimate sighting rates was limited to on-effort observations made during Beaufort sea state conditions of four or less during systematic, connector, random, and transit effort leg types (defined in Smultea and Bacon 2011). The latter effort totaled 2024 km or 10.7 hours. Note that this total effort does not meet the criteria of line-transect methodology, which requires more conservative filtering (e.g., consistent altitude and speed, effort during pre-determined survey lines meeting certain conditions and assumption, etc.). We included the less-conservative aforementioned effort and conditions in order to maximize sample size given the relatively small amount of effort expended during the one May 2011 aerial. We have not conducted power analyses on the May 2011-only data for reasons discussed previously. Sightings rates herein are estimated based on sightings per 1000 km of point-to-point flight rather than per 1 km as done in previous reports; this was to facilitate the reporting of whole numbers rather than decimal fractions of animal sightings. Note again that these sightings rates cannot be used to calculate areal density or abundance like DISTANCE analyses can (see **Appendix B** of monitoring report for abundance and density estimates from eight SOCAL aerials).

As illustrated in **Table 1**, overall sighting rates of dolphins were approximately one-third higher than sightings rates of whales. Sighting rates of blue, fin and unidentified whales were the same

(2.0 sightings/1000 km flown) based on the small sample sizes (**Table 1**). All other whale sighting rates were considerably less. Unidentified whales typically consisted of whales that were seen at a distance but for which there was not enough time to circle to confirm species. Common dolphin species had the highest overall sighting rate (11.0 groups/1000 km flown) which was over twice as high as that of Risso's dolphins (5.0 groups/1000 km flown). Based on examination of photos, three of the eight common dolphin species sightings were identified to species but these sightings were combined with common dolphin species unknown due to small sample sizes (**Table 1**).

Table 1. Sighting rates of marine mammals during the May 2011 SOCAL aerial survey. Estimates based on-effort observations made during systematic, connector, random, and transit effort leg types totaling 2024 km or 10.7 hours. (Note: all effort included here does not meet the criteria of line-transect methodology).

Species (Common Name)	May-11			
	Total Sightings	Sightings /1000 km	Sightings /1000 nm	Sightings /hour
Whales	**15**	**7.4**	**13.7**	**1.4**
Blue Whale	5	2.0	5.0	0.5
Fin Whale	4	2.0	4.0	0.4
Humpback Whale	1	0.5	0.9	0.1
Sperm Whale	1	0.5	0.9	0.1
Unidentified Baleen Whale	4	2.0	4.0	0.4
Unidentified Medium Whale	1	0.5	0.9	0.1
Dolphins	**24**	**12.0**	**22.0**	**2.2**
Risso's Dolphin	5	2.0	5.0	0.5
Common Dolphin sp. (includes 2 sightings of short-beaked and 1 sighting of long-beaked common dolphins)	11	5.4	10.0	1.0
Bottlenose Dolphin	3	1.0	2.0	0.3
Unidentified Dolphin	5	2.0	5.0	0.5
Pinnipeds	**9**	**4.0**	**8.0**	**0.8**
California Sea Lion	9	4.0	8.0	0.8
Overall Marine Mammal	**49**	**24.2**	**44.8**	**4.5**

Behavior. Behavioral results are discussed below. Results of the first approach involving initially observed behaviors are first described by species. This is followed by results of focal session data using the same variables but involving multiple observations from the same sightings. As discussed above, in May 2010, a total of 49 sightings were observed of eight confirmed species where at least one of the behavioral parameters was determined/recorded for initially observed behaviors. Mean initial behavioral state, heading, and/or dispersal data were recorded for most sightings when such information could be determined. Based on focal follow data, sample sizes by species were considered large enough (n>5) to conduct meaningful summary statistic for only three species: blue whales (n = 18), fin whales (n=7) and Risso's dolphins (n=6). Mean group sizes, and means and/or frequency distributions of headings, mean and maximum dispersal distances, and behavior states are presented in **Tables 1-3** and **Figures 1-13** for initially observed behaviors and for focal follow groups. Sample sizes were not large enough to assess behavior relative to diurnal or other time trends.

Behavior State. Initial behavior state data were determined for six species based on sample sizes ranging from 6-13 (**Table 2**). Whales predominantly traveled, although blue whales in May also were observed milling/foraging. Risso's dolphins in particular also predominantly traveled and rarely exhibited surface-active behaviors, unlike common dolphins. These trends are similar to those reported during previous SOCAL aerial surveys.

Group Size. As anticipated, mean group size of common dolphin species was highest followed by bottlenose dolphins and Risso's dolphins (**Table 2, Figure 1**). However, there was considerable variation in group size among dolphin species. Mean group size of fin and blue whales was 1.3 and 1.2, respectively, with little variation in group size based on the relatively small standard deviations (**Table 2**).

Dispersal Between Nearest Neighbors. Mean minimum dispersal distance between nearest neighbors was 1 body length for nearly all species (**Table 2**) with little variation based on standard deviations, except among bottlenose dolphins. However, sample sizes were predominantly small. Mean maximum dispersal distance was much more variable (**Table 2**). Bottlenose dolphins had the highest mean dispersal distance of 13 body lengths (BL), followed by blue whales (11.0 BL) and fin whales (6.0 BL). However, the standard deviation for the latter means was relatively large, which is not surprising considering the small sample sizes (n <11) (**Table 2**). An exception was the common dolphin species which tended to stay quite cohesive within subgroups: mean maximum dispersal was 3.0 ± 0.59 based on the largest sample size of all species for the May survey (n=12). In general, dispersal among whales was relatively larger than among dolphins in terms of body lengths (**Table 2**).

Orientation/Heading. Mean heading/orientation was generally southward or southwestward for most species, although there was considerable variability (**Table 2**). **Figures 12 and 13** suggest that whales in particular had headings that were quite variable. This was likely related to foraging by blue whales in particular. For example, during surfacing bouts, blue whales tended to maintain a consistent heading but by the next surfacing sequence would be often headed in another orientation, resulting in overall staying in the same general area.

Table 2. Number of groups sighted and summary statistics based on initially observed behavioral parameters from the May 2011 SOCAL aerial survey. BL = Body lengths; n = sample size. Dispersal distances were not applicable to groups of size 1 animal.

Species	Mean ± SD Group Size (n)	Mean ± SD of Smallest Initial Group Dispersal in BL (n)	Mean ± SD of Greatest Initial Group Dispersal in BL (n)	Mean ± SD of Initial Group Heading (n)	Initial Behavior State (percent of species sample size)				
					No. of Groups with Initial Behavior State	Travel/ Swim	Surface-Active Travel	Mill/ Forage	Surface-Active Mill/ Forage
Common dolphin sp.	185.0 ± 103.96 (n=13)	1.0 ± 0.17 (n=12)	3.0 ± 0.59 (n=12)	226 ± 131 (n=5)	9	34%	21%	8%	37%
California sea lion	3.0 ± 3.75 (n=13)	2.0 ± 0.00 (n=1)	2.0 ± 0.00 (n=1)	190 ± 98 (n=5)	13	60%	4%	33%	4%
Risso's dolphin	11.0 ± 6.23 (n=9)	1.0 ± 0.00 (n=8)	4.0 ± 3.37 (n=8)	213 ±522 (n=8)	9	80%	1%	17%	2%
Fin whale	1.3 ± 0.34 (n=9)	1.0 ± 0.00 (n=1)	6.0 ± 8.94 (n=3)	181 ± 93 (n=8)	9	92%	4%	4%	-
Blue whale	1.2 ± 0.27 (n=12)	1.0 ± 0.34 (n=3)	11.0 ± 19.44 (n=3)	206 ± 72 (n=10)	12	85%	4%	11%	-
Bottlenose dolphin	21.0 ± 16.02 (n=6)	1.0 ± 1.19 (n=5)	13.0 ± 18.89 (n=5)	200 ± 109 (n=6)	6	54%	21%	13%	13%
Sperm whale	24 ± n/a (n=1)	n/a	n/a	n/a	1	100%	-	-	-

Table 3. Number of focal groups circled and associated summary statistics from the May 2011 SOCAL aerial survey. Limited to the three species with at least 5 sightings. Dispersion distance was not applicable (n/a) for sightings with group size of one animal.

	Species		
	Fin Whale	**Blue Whale**	**Risso's Dolphin**
Total Focal Groups	7	18	6
Mean Orientation (degrees magnetic)	102.5	210	111
Standard Deviation (SD)	50.35	44.00	20.00
No. 30-min Scan Samples	12	30	11
Minimum Dispersal (Body Lengths (BL))	n/a	n/a	2
SD	n/a	n/a	0.31
No. 30-min Scan Samples	n/a	n/a	66
Maximum Dispersion (BL)	n/a	n/a	4
SD	n/a	n/a	0.79
No. 30-min Scan Samples	n/a	n/a	66

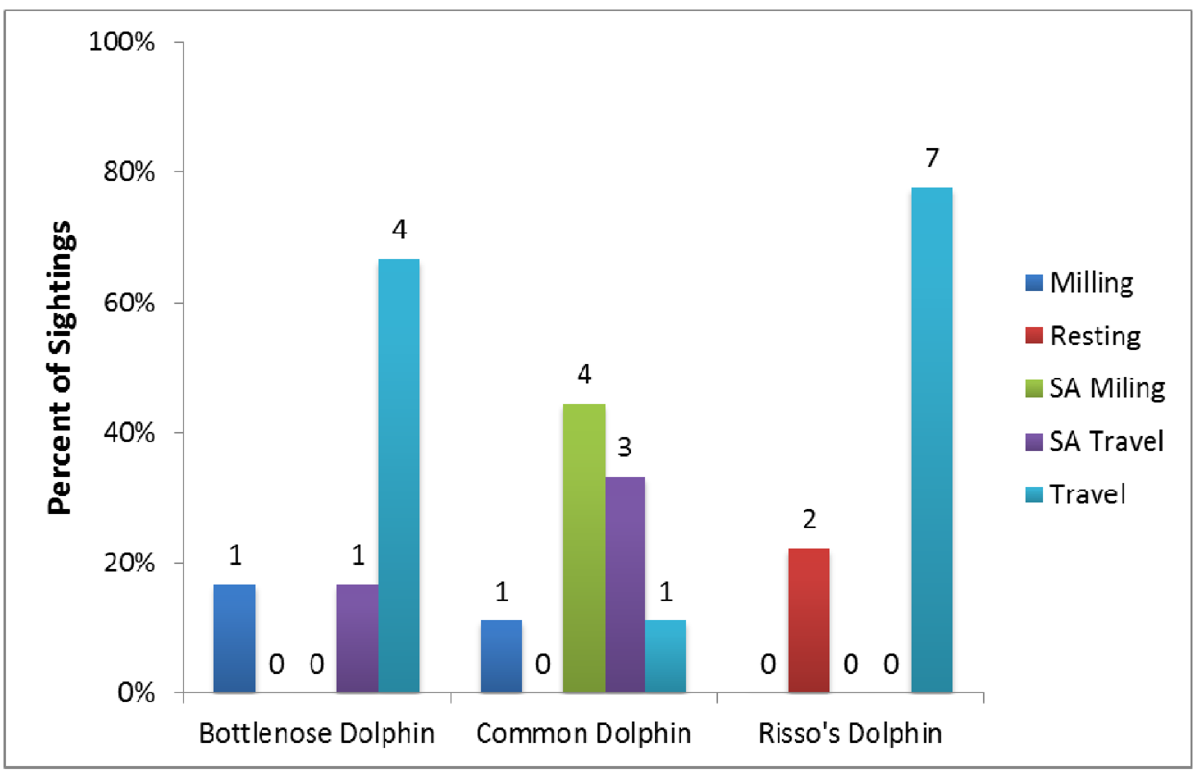

Figure 1. Percent of dolphin sightings engaged in various behavioral states when first observed. Sample sizes indicated above bars. Note: SA = surface active.

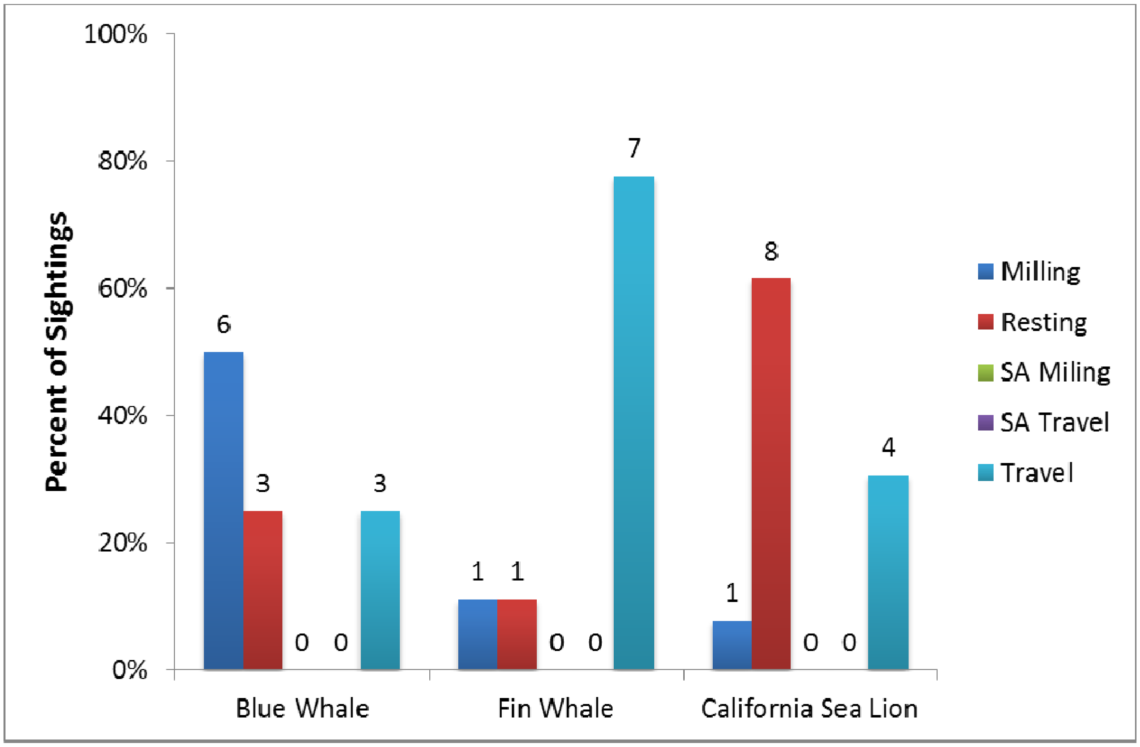

Figure 2. Percent of whale and California sea lion sightings engaged in various behavioral states when first observed. Sample sizes indicated above bars. Note: SA = surface active.

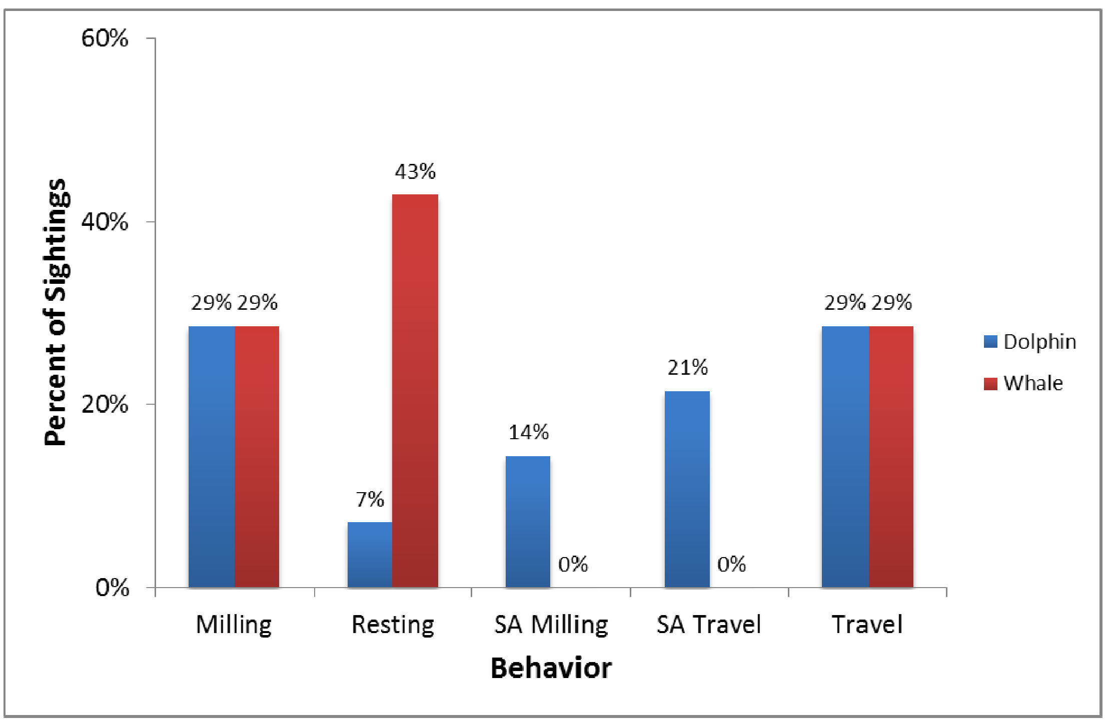

Figure 3. Percent of combined dolphin and whale sightings engaged in various behavioral states when first observed. Sample sizes indicated above bars. Note: SA = surface active.

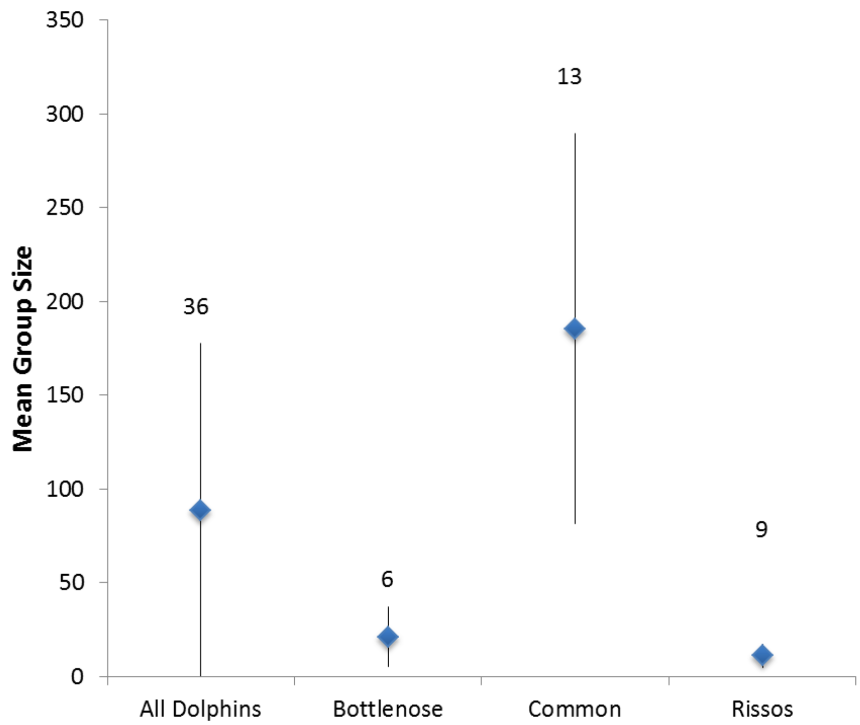

Figure 4. Mean and standard deviation of group size by dolphin species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars.

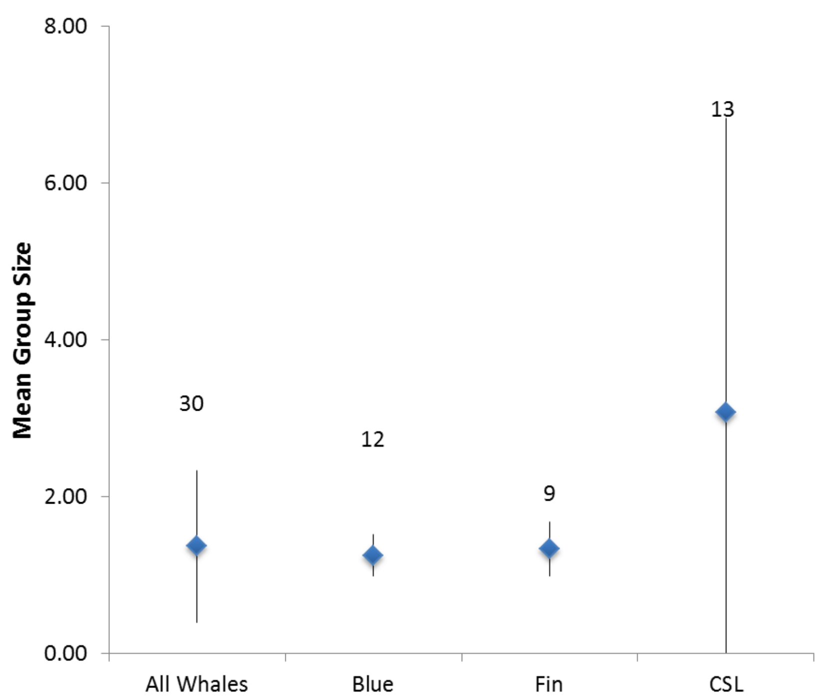

Figure 5. Mean and standard deviation of group size by whale and California sea lion (CSL) species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars.

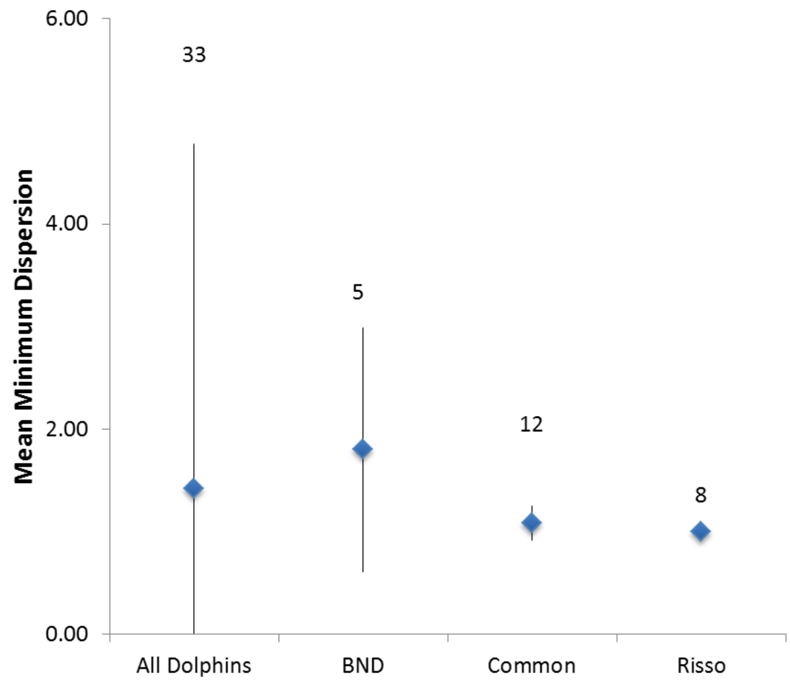

Figure 6. Mean and standard deviation of minimum dispersion distance in body lengths (BL) between nearest neighbors within a subgroup by dolphin species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars. Note: BND = Bottlenose dolphin.

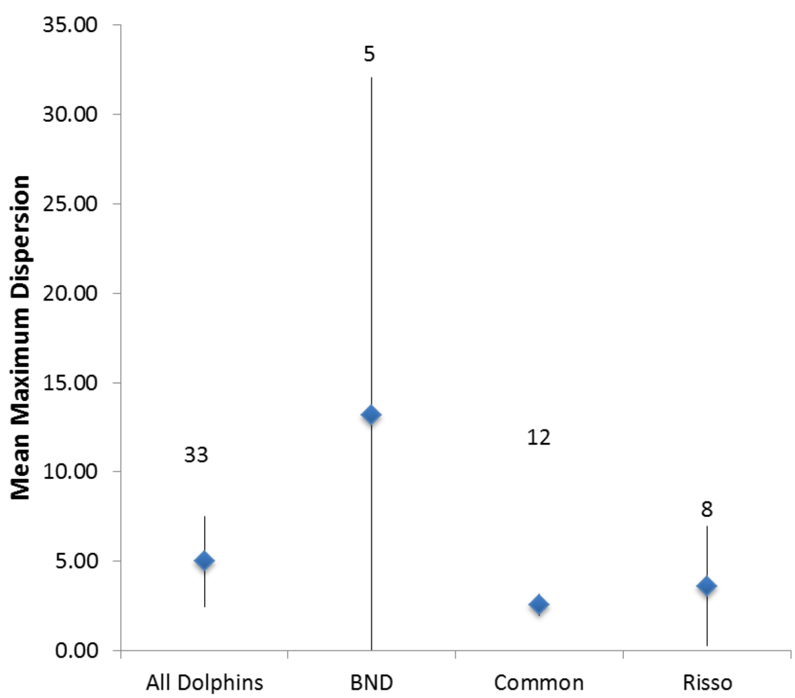

Figure 7. Mean and standard deviation of maximum dispersion distance in body lengths (BL) between nearest neighbors within a subgroup by dolphin species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars. Note: BND = Bottlenose dolphin.

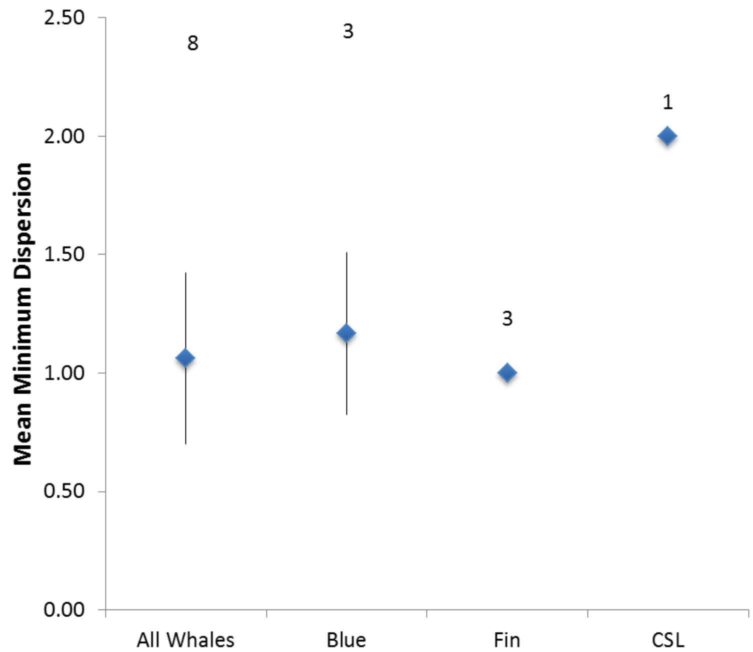

Figure 8. Mean and standard deviation of minimum dispersion distance in body lengths (BL) between nearest neighbors within a subgroup by whale and California sea lion (CSL) species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars.

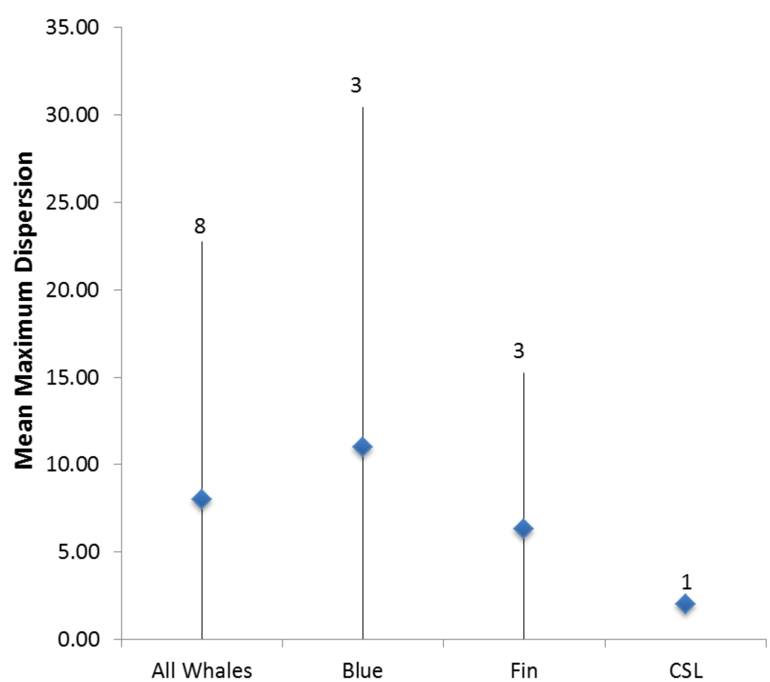

Figure 9. Mean and standard deviation of maximum dispersion distance in body lengths (BL) between nearest neighbors within a subgroup by whale and California sea lion (CSL) species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars.

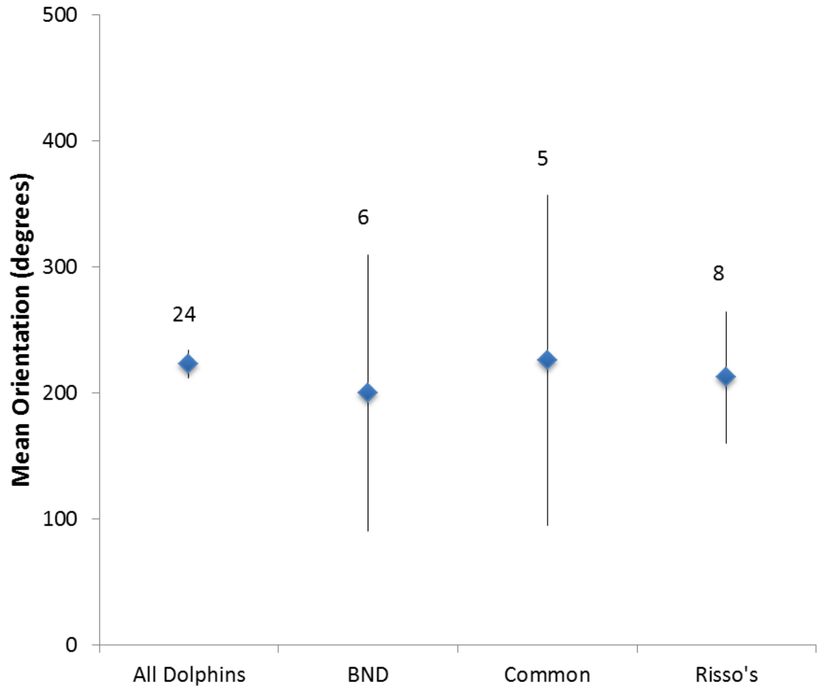

Figure 10. Mean and standard deviation of orientation/heading in degrees magnetic between nearest neighbors within a subgroup by dolphin species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars. Note: BND = Bottlenose dolphin.

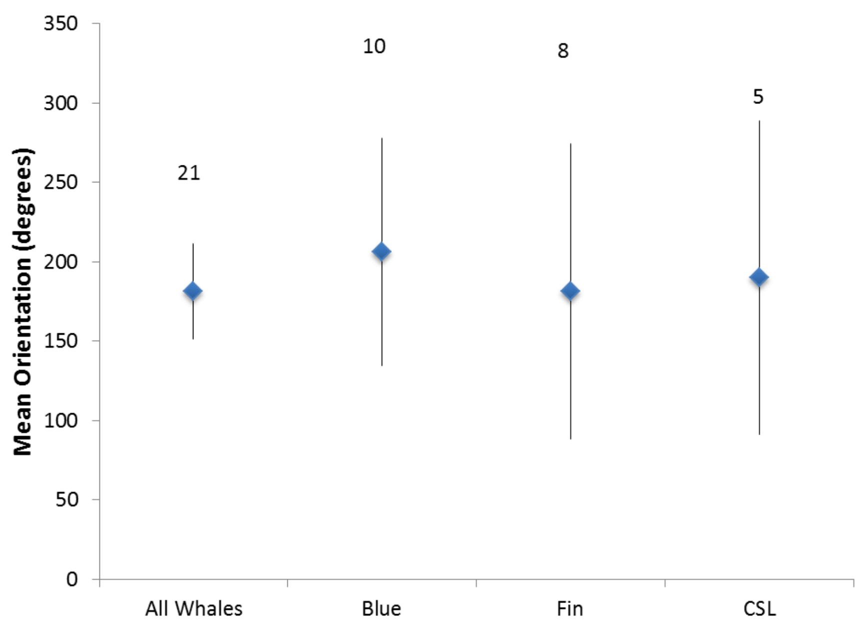

Figure 11. Mean and standard deviation of orientation/heading in degrees magnetic between nearest neighbors within a subgroup by whale and California sea lion (CSL) species during the May 2011 SOCAL aerial survey. Sample sizes indicated above bars.

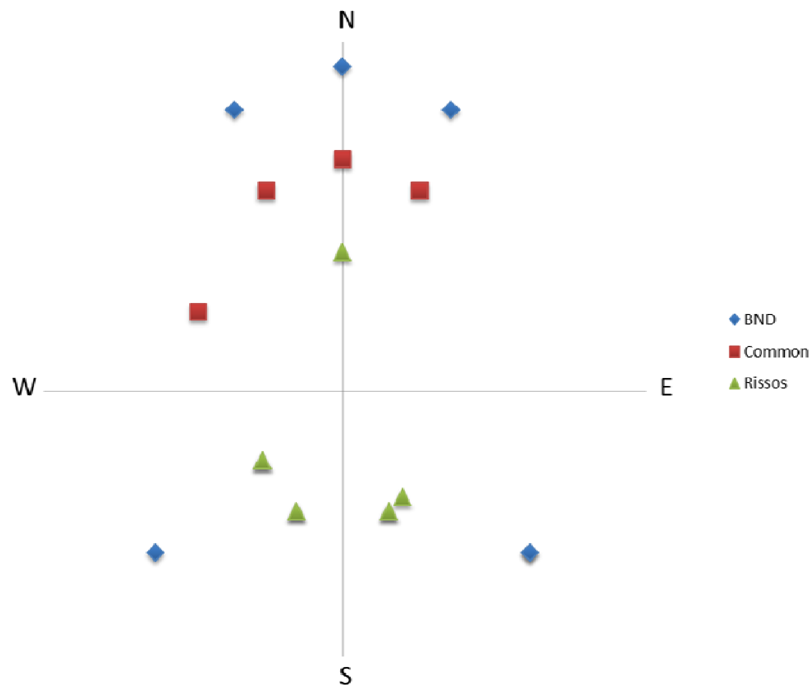

Figure 12. Distribution of first observed orientation/heading in degrees magnetic by dolphin species during the May 2011 SOCAL aerial survey. Note: BND = Bottlenose dolphin.

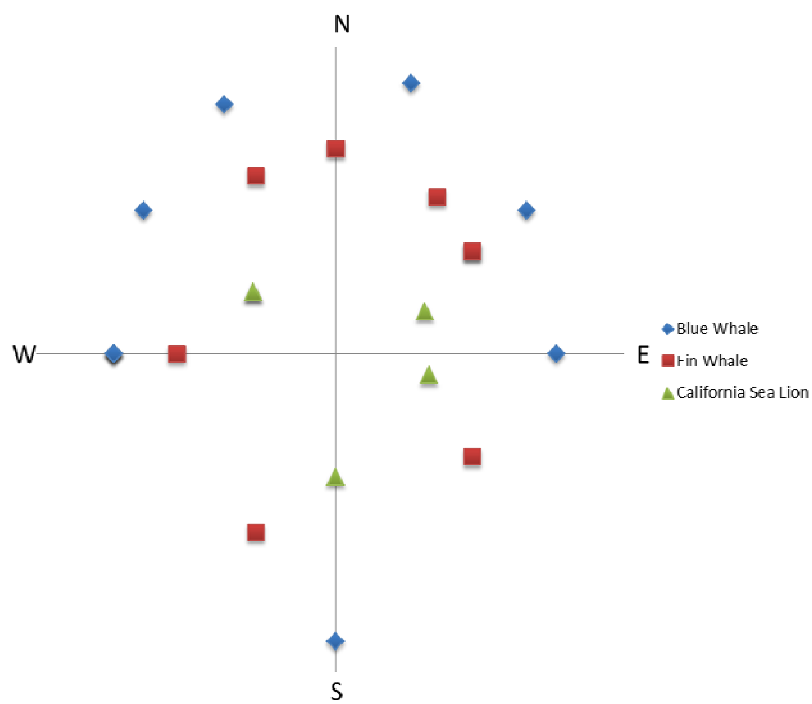

Figure 13. Distribution of first observed orientation/heading in degrees magnetic by whale and California sea lion species during the May 2011 SOCAL aerial survey.

Pre-Flight and In-Flight Communications

Conducting the aerial surveys involved considerable planning, communications and clearances given the logistical complexity and high degree of safety planning associated with operating in and near the busy airspace near the southern California coastline and on the SOCAL Range, especially during the MTEs. In-flight communications protocol was also critical to quickly communicate information between the aircraft and observation crews for data efficiency and safety. Coordinating communications between the aircraft crew and other researchers in the field also required planning.

Each morning, for the purposes of flight planning, the pilot checked the local aviation weather and forecasts through the NOAA online aviation website. The pilot then called the Navy's flight tower (i.e., "Beaver Control") for local weather and an updated range activity schedule, and requested clearance to enter Navy airspace, as relevant. NAOPA was nearly always clear for our flights except in the SHOBA range area south and east of SCI, which was frequently active and thus inaccessible to our aircraft. Clearance to fly SOAR was usually requested several weeks before the scheduled survey by the NTR in communication with SCORE. Navy activity schedules often changed, so the daily pre-flight check-in was always conducted by the pilot. Prior to entering Navy air space at SOAR, the pilot called Beaver on the aviation radio to request updated access to SOAR as applicable. When the aircraft flew near "hot" active areas, Beaver contacted the pilot on the radio and requested that the survey plan change its heading and/or location as applicable to avoid active areas. Entering the Silver Strand range required additional separate clearance from the Navy's North Island tower and other adjacent airspace that had to be updated just prior to each entry of the busy airspace in that area.

In-flight communications protocol included the observers remaining quiet during takeoff and landings, and whenever Beaver or other control towers were communicating with the pilot(s). The pilots were advised to remain quiet during focal observations as to not preclude the observers' need to communicate data to one another. They were also advised not to alert the observers of any sightings until the sighting had passed the mid-line of the plane and was not seen by the observers; the latter is important with respect to abundance-estimating protocol. When radio communications were busy, the pilot could isolate him or herself from the observers as needed, whereby the pilot could still hear the observers but the observers could not hear the pilot and other radio communications.

Across-platform communications were used between the survey aircraft crew and other researchers, including the BRS study, Cascadia small vessel crew, and UCSC/SIO small vessel crew. This was accomplished by pre-designating three marine VHF channels through which to communicate, as the channels had to be pre-programmed in the aircraft. The pilot or co-pilot was the only aircraft crew who could communicate directly with other research platforms. This was a less-than-ideal situation, as it decreased efficiency of communications. For example, during the BRS study, the delay in relaying the locations and surfacings of cetaceans between the two platforms delayed the ability to respond and relocate animals. It also was difficult to share detailed information between researchers in the air and on the water. Future coordinated efforts should involve use of a direct communications system between researchers on different platforms. When within cell phone range, texting between aircraft and vessel observers in coastal areas was also used with limited success.

Recommendations and Additional Notes

1. It is critical to have at least one opening window from which an observer can take high-definition video and photographs for species identification and detailed behavioral observations. This was demonstrated by a comparison of photos and video taken during March 2011 (through an opening window in the rear left seat of the Partenavia aircraft) vs. the April 2011 survey (either through double-paned Plexiglas or by the non-flying pilot, a novice photographer, through an opening window on the left front pilot side of the Twin Commander). See **Appendix A** for comparison photographs.
2. If the Twin Commander had opening portholes in the windows of the second-row seats, it would provide the advantage of a longer range than the Partenavia. A longer range is advantageous for the SOCAL survey: it maximizes survey time on SOAR which is approximately 150 km (81 nm) west of San Diego. However, the Twin Commander contracted during the April survey costs considerably more than the Partenavia. Additional research indicated that other Commanders can be leased in the region that are equipped with opening windows or bubble windows that are important to maximize efficacy of aerial surveys.
3. The option of using a Twin Otter aircraft should be considered. Though the hourly cost of this lease (as preliminarily investigated) would be about twice that of the Twin Commander, it is considered an ideal aircraft for conducting and videotaping focal behavioral follows, particularly given its long range (up to 7–8 hours) and ability to circle relatively slowly compared to other twin-engine, fixed-wing aircraft (pers. comm., Dr. B. Würsig 2011).
4. Aspen Helicopters, the contractor for the Partenavia, indicated that aircraft fuel can be carried via vessel to San Clemente Island (SCI) to refuel the aircraft. (Only helicopter fuel is currently available at SCI.) This would increase the range of the Partenavia at SOAR by allowing it to refuel at SCI. Beaked and fin whales tend to occur on the western and northwestern edges of SOAR where minimal effort has been expended by aircraft and small vessels given the distance from San Diego (and SCI).
5. Another flight platform option to consider is a helicopter stationed at SCI. Helicopter fuel is available on SCI. Two short flights (2 to 2.5 hours) in a helicopter on SOAR could be made each day from SCI with enough time to fly all SOAR transect lines and leave time for focal follows, based on past experience. This includes a feasibility survey conducted with the helicopter in July 2010 (Smultea et al. 2010).
6. Mysticetus should continue to be used during subsequent aerial surveys. It should also be tailored for use during vessel-based surveys to facilitate consistency of data collection. This software is easily adapted by the user to include specific parameters of interest.
7. Funding should be provided to analyze the following data:
    a. Video and behavioral data in detail for the February, March, and April 2011 surveys. This task should include transcription of videos, integration of videos with field behavioral notes and audio, and plotting of movement tracks in 3D on Google Earth with other data layers of relevance (e.g., surface temperature, bathymetry) to identify any potential patterns. These data should be compared with periods when sonar was on and off relative to distance and estimated received levels of sonar

sounds and the presence and behavior of nearby Navy ships. They should also be compared and combined with previous behavioral data collected since 2008 on the SOCAL Range during similar aerial surveys. This synthesis is needed to maximize sample sizes to identify trends and provide robust behavioral baseline data. From compiled data, statistical power analyses can be run to assess the variability in the data and the minimum sample size needed to identify any significant changes that might result from exposure to Navy activities.

b. February–May 2011 data should be further processed, filtered, and edited to be suitable for conducting DISTANCE analyses of density and abundance. These data should then be combined with data already analyzed in DISTANCE for SOCAL 2008–2010 aerial survey (Smultea et al. in prep.). The latter requires Geographical Information System (GIS) analyses to accurately quantify and identify the time and distances expended in each type of survey leg effort. In particular, GIS analyses are needed to filter the data to identify the subsample of on-effort periods that meet the basic requirements for analysis of sighting data for density and abundance estimates with DISTANCE software—on-effort periods on systematic lines while flying at 1,000-ft altitude and 100 kts with both observers on full effort in environmental conditions acceptable for given species.

c. The approximately 15+ systematic focal sessions collected in 2008-2011 from various cetacean species (mainly Risso's dolphins) in SOCAL while the aircraft circled for about 5 minutes at set descending altitudes (e.g., 2,000-, 1,500- and 1,000-foot altitude) should be analyzed in detail to assess behavior relative to the observation platform.

8. We recommend a detailed behavioral analysis be conducted for sightings that occurred when a Navy vessel was in view.

9. A feasibility/pilot study should be considered where the aircraft is opportunistically flown during playback of sonar sounds for the Navy-funded SOCAL Behavioral Response Study (BRS). The aircraft could be on stand-by mode awaiting periods before, during, and after playbacks by the BRS study. During the latter periods, preferably sequentially during these periods, the aircraft could conduct focal follows of other marine mammals that might be sighted within a distance of the playback vessel where the projected sonar sounds are audible to that species and focal group. The aerial survey in September 2010 was able to do this. However, the BRS vessel was busy with previous focal groups at the time and was not able to follow the group. Following this approach would potentially add to the BRS sample size of the behavior of marine mammals exposed to playbacks of sonar and other sounds.

10. A feasibility/pilot study should be considered where the aircraft drops sonobuoys equipped with GPS from the aircraft near priority focal follow sessions on species of interest. This would allow recording of underwater vocalizations of select species where species, group size/age class, behavior state, and other social structure information could be linked with confirmed species. The latter is a critical need of the passive acoustics studies in SOCAL and elsewhere; there are still many sounds that remain to be identified/linked with specific species.

11. A problem encountered was that we did not have an ops number from the Navy that was specific to what we were going to be doing. They would say the area was "hot" (i.e.,

inaccessible) and the pilot would say "I believe it's hot for us"---when the hot was us. Normally, the pilot recognized that the area was hot for our observation aircraft if the Navy indicated that "surface to 5000 ft" was hot. The Navy would subsequently check and clear us for access. Having an ops number in the future would facilitate and expedite our access to normally restricted areas.

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Appendix A. Photographs

Photo 1. Sei/Bryde's whales photographed 28 September 2010 by B. Würsig under NMFS permit 15369.

Photo 2. Bryde's whale photographed 24 September 2010 by B. Würsig under NMFS permit 15369.

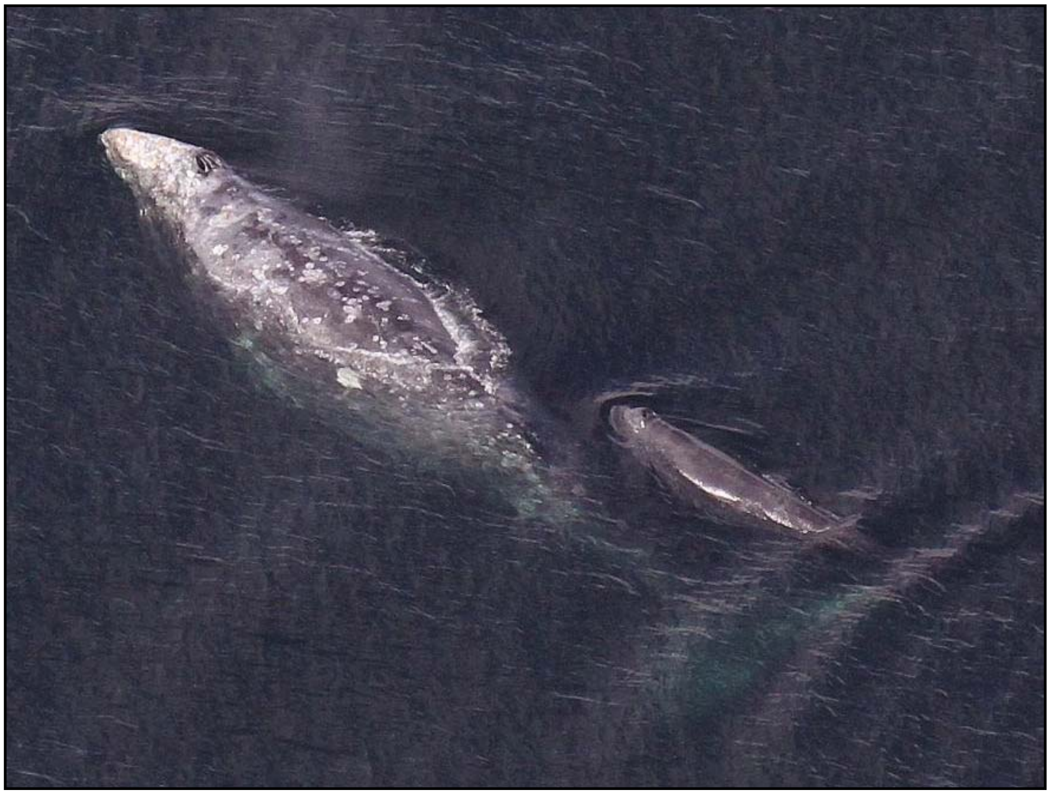

Photo 3. Gray whale mother and very young calf. Photographed 15 February 2011 by B. Würsig under NMFS permit 14451.

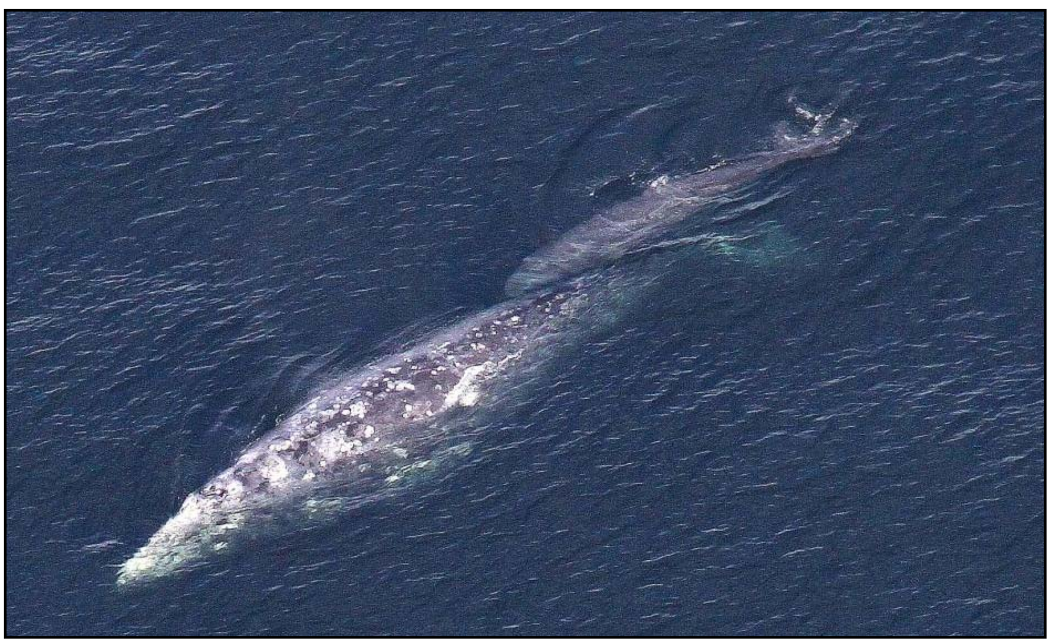

Photo 4. Gray whale mother and calf. Photographed 15 February 2011 by B. Würsig under NMFS permit 14451.

Photo 5. Fin whale. Photographed 15 February 2011 by B. Würsig under NMFS permit 14451.

Photo 6. Short-beaked common dolphins. Photographed 15 February 2011 by B. Würsig under NMFS permit 14451.

Photo 7. Risso's dolphins. Photographed 31 March, 2011, by T. Jefferson under NMFS permit 14451 through an open window on the Partenavia aircraft at altitude 1,500 feet.

Photo 8. Minke whales. Photographed 31 March 2011, by B. Würsig under NMFS permit 14451.

Photo 9. Northern right whale dolphins at SOAR. Photographed 01 April 2011, from the open window of the Partenavia at altitude 1,500 feet by D. Engelhaupt under NMFS permit 14451.

Photo 10. Fin whale photograph taken through the closed, double-paned Plexiglass window of the Twin Commander on 14 April 2011. Compare the degraded quality/resolution of this photo vs. photo of minke whales taken through the opening window in the Partenavia aircraft. Photographed by B. Würsig under NMFS permit 14451.

Photo 11. Blown-up photograph of two common dolphins photographed on 16 April 2011 through the small opening port window by the co-pilot (while the other pilot flew the plane). Photographed under NMFS permit 14451.

Photo 12. Porpoising long-beaked common dolphins photographed 16 April 2011, by the co-pilot (while the other pilot flew the plane) through the open window in the Twin Commander under NMFS permit 14451.

Photo 13. Dead humpback whale with blue shark photographed 10 May 2011 from the open window of the Partenavia by M. Smultea under NMFS permit 14451.

Photo 14. Fin whale photographed 10 May 2011 from the open window of the Partenavia at altitude 1,500 feet by M. Smultea under NMFS permit 14451.

Photo 15. Sperm whale photographed 14 May 2011 from the open window of the Partenavia by D. Steckler under NMFS permit 14451.

Photo 16. Sperm whales with northern right whale dolphins (left center and Risso's dolphins (top center) photographed 14 May 2011 from the open window of the Partenavia by D. Steckler under NMFS permit 14451.

Photo 17. Sperm whale and calf with Risso's dolphin photographed 14 May 2011 from the open window of the Partenavia by D. Steckler under NMFS permit 14451. Note sperm whale's open jaw.

Photo 18. Sperm whale and calf photographed 14 May 2011
from the open window of the Partenavia
by D. Steckler under NMFS permit 14451.

Photo 19. Sperm whales photographed 14 May 2011 from the open window of the Partenavia by D. Steckler under NMFS permit 14451. Risso's and northern right whale dolphins on left in front of sperm whales.

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Appendix B. Figures

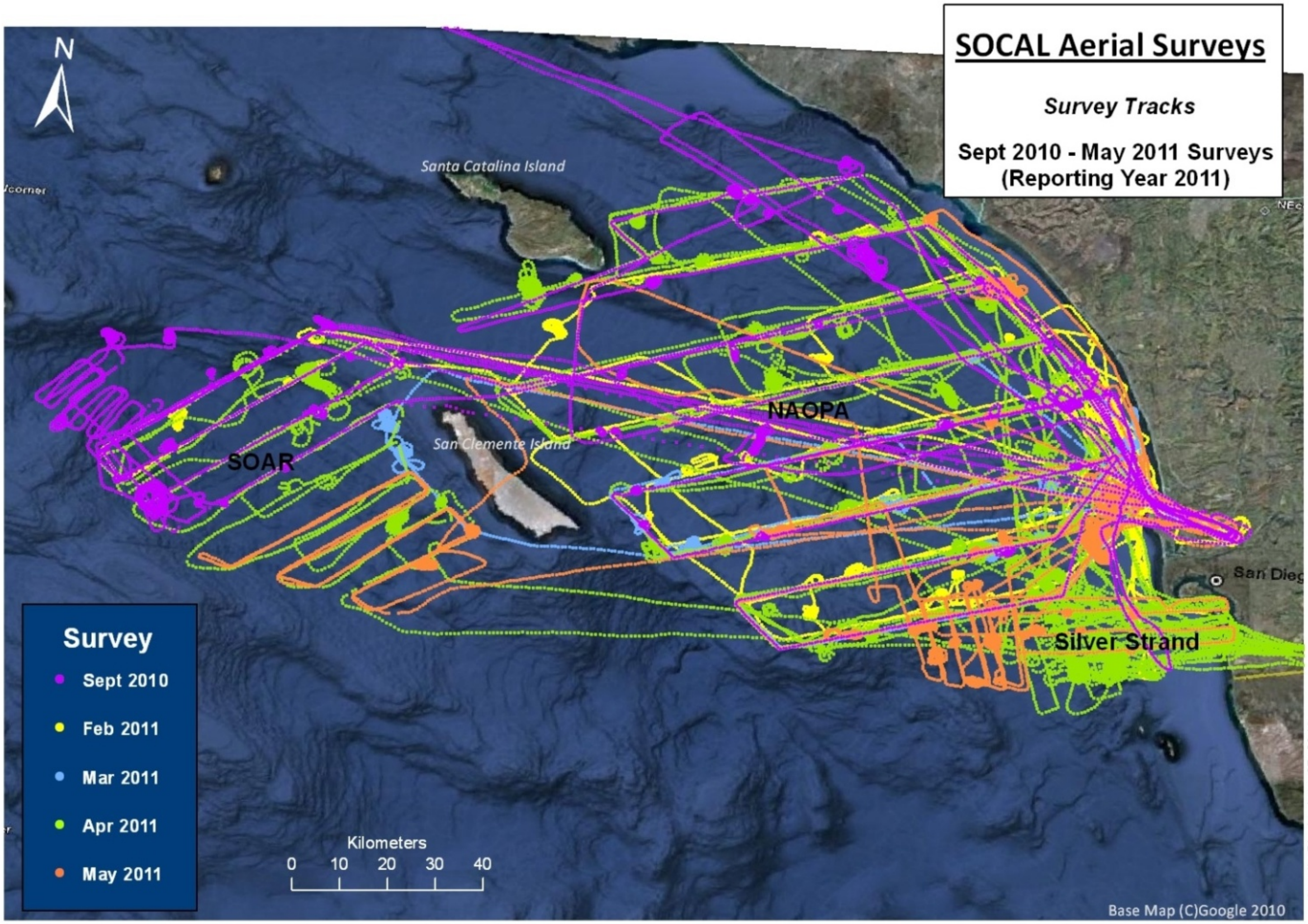

Figure 1. All aerial track lines made during the September 2010 and February-May 2011 aerial monitoring surveys in SOCAL, color-coded by survey month.

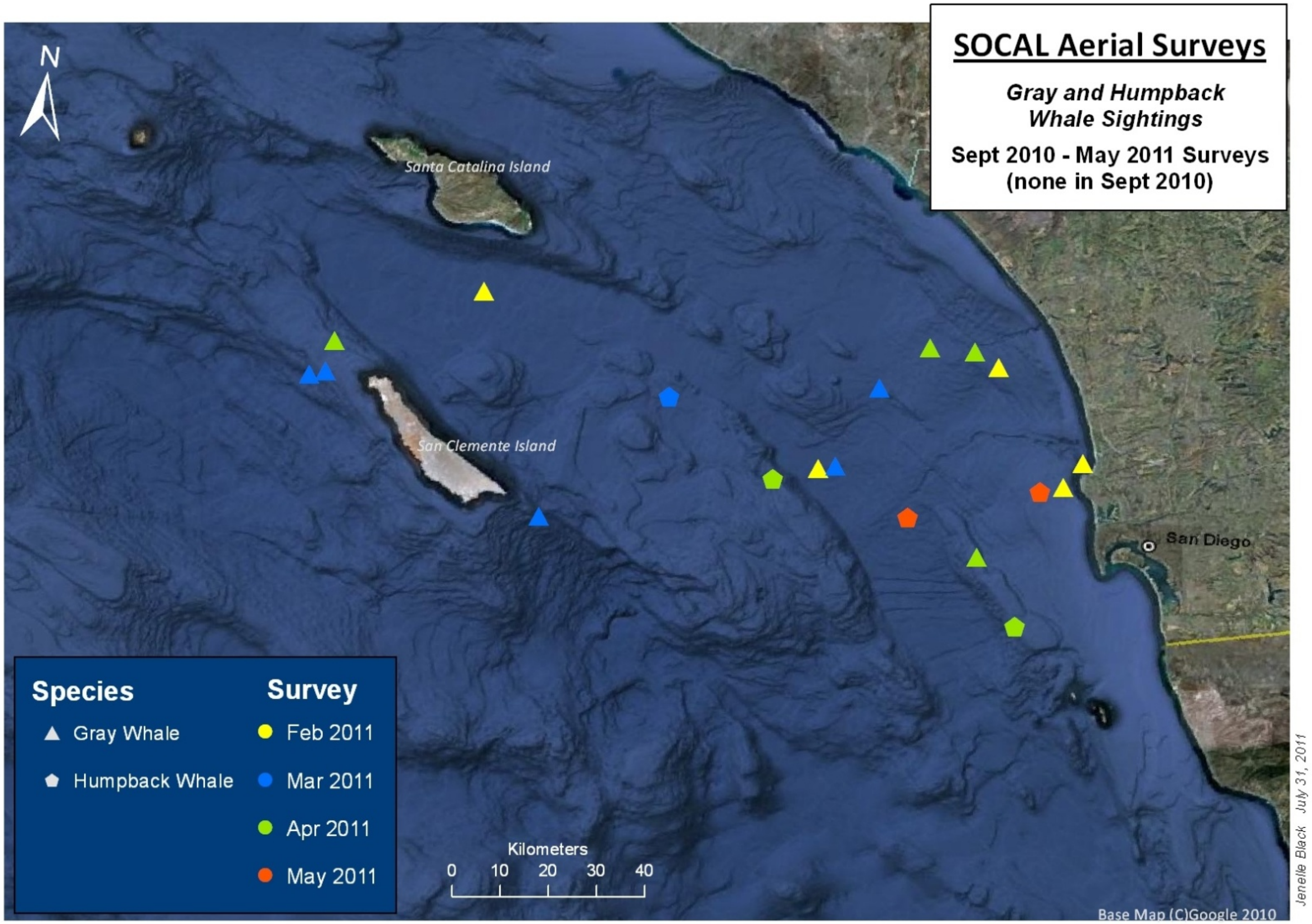

Figure 2. Gray whale and humpback whale sightings color-coded by month, during aerial surveys in SOCAL September 2010 and February – May 2011.

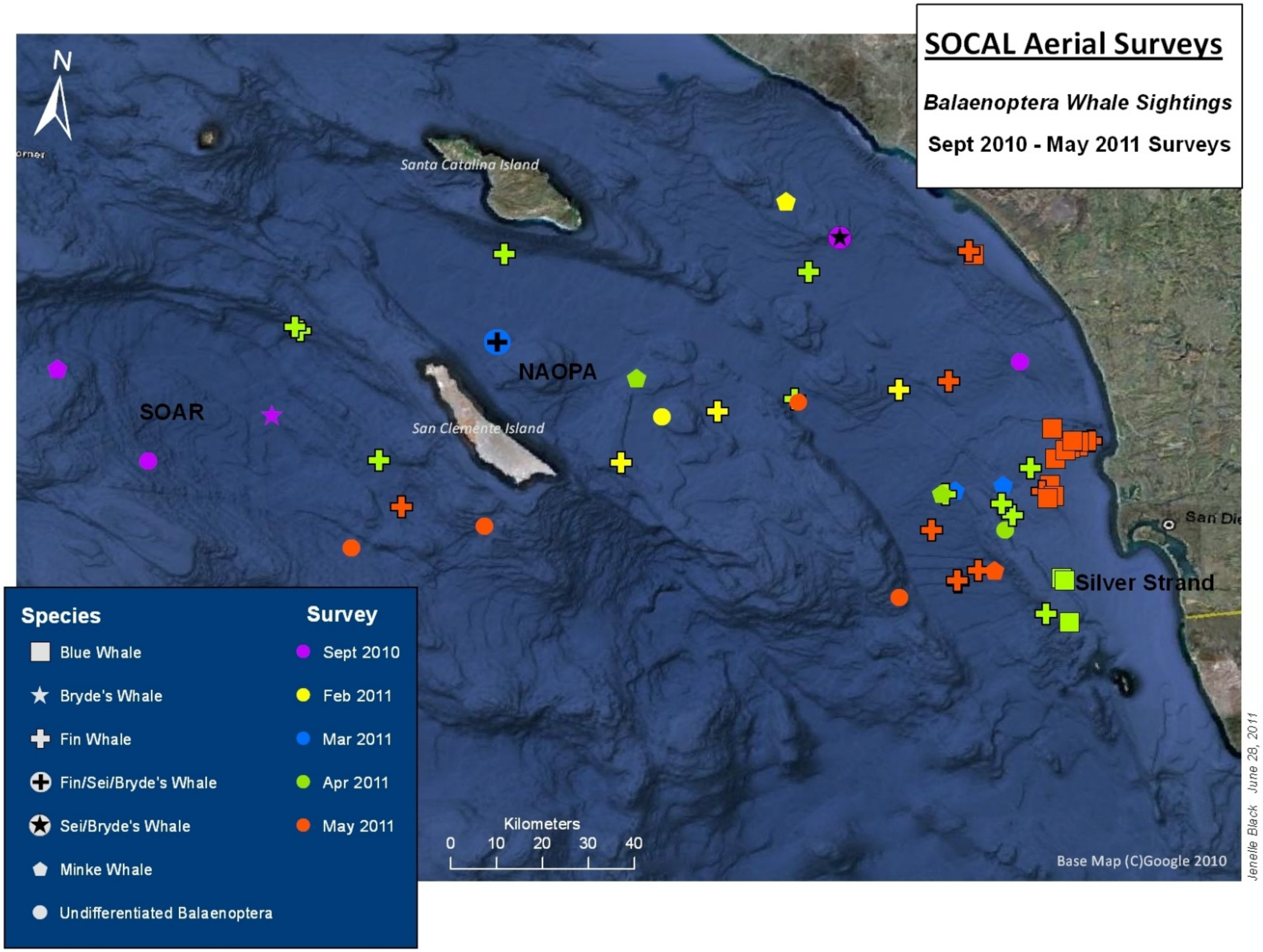

Figure 3. Balaenoptera whale sightings color-coded by month, during aerial surveys in SOCAL September 2010 and February – May 2011.

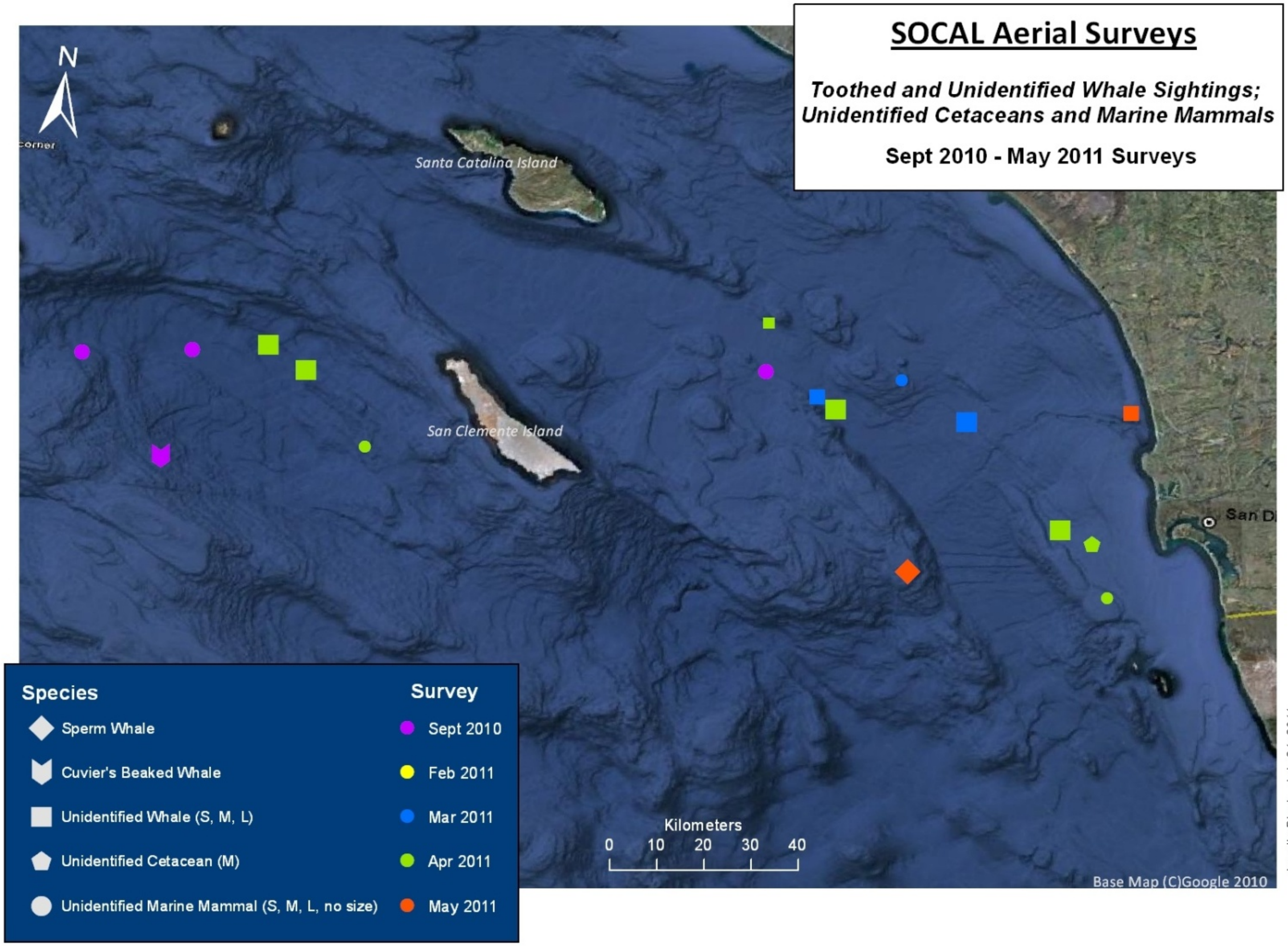

Figure 4. Toothed and unidentified whale sightings color-coded by month, during aerial surveys in SOCAL September 2010 and February – May 2011.

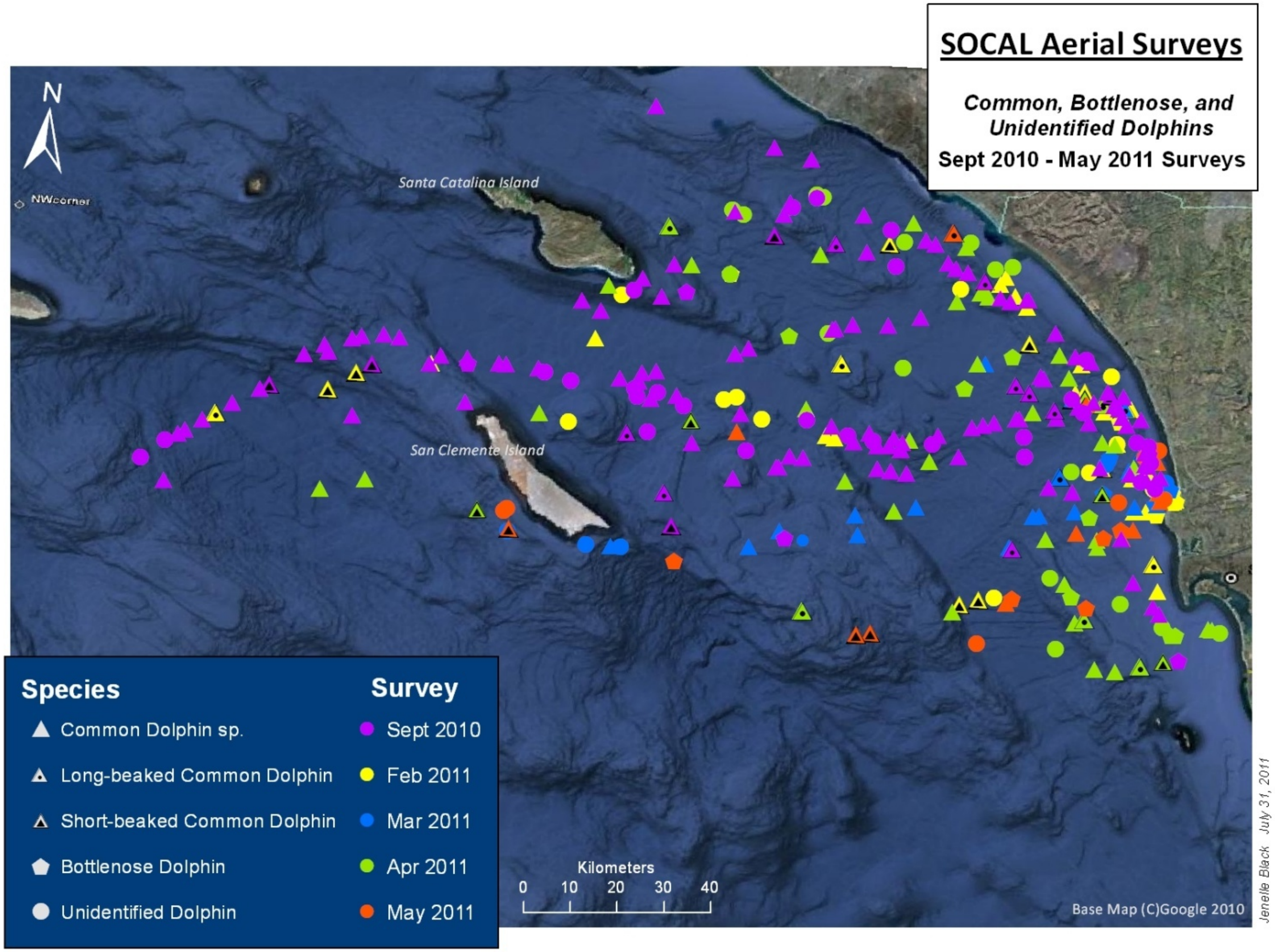

Figure 5. Common dolphin, bottlenose dolphin and unidentified dolphin sightings by species color-coded by month, during aerial surveys in SOCAL September 2010 and February – May 2011.

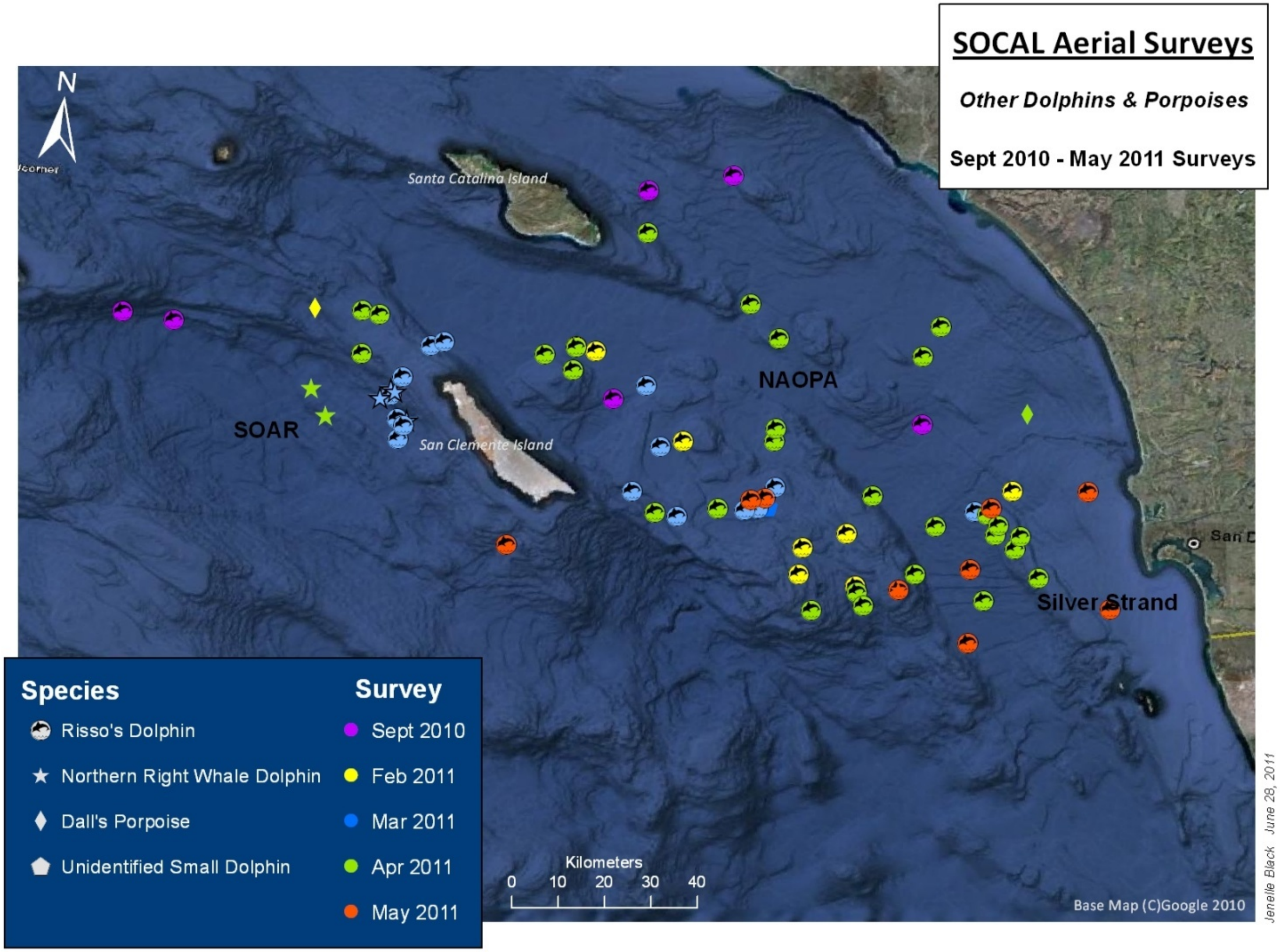

Figure 6. Risso's dolphin, Northern right whale dolphin and Dall's porpoise sightings by species color-coded by month, during aerial surveys in SOCAL September 2010 and February – May 2011.

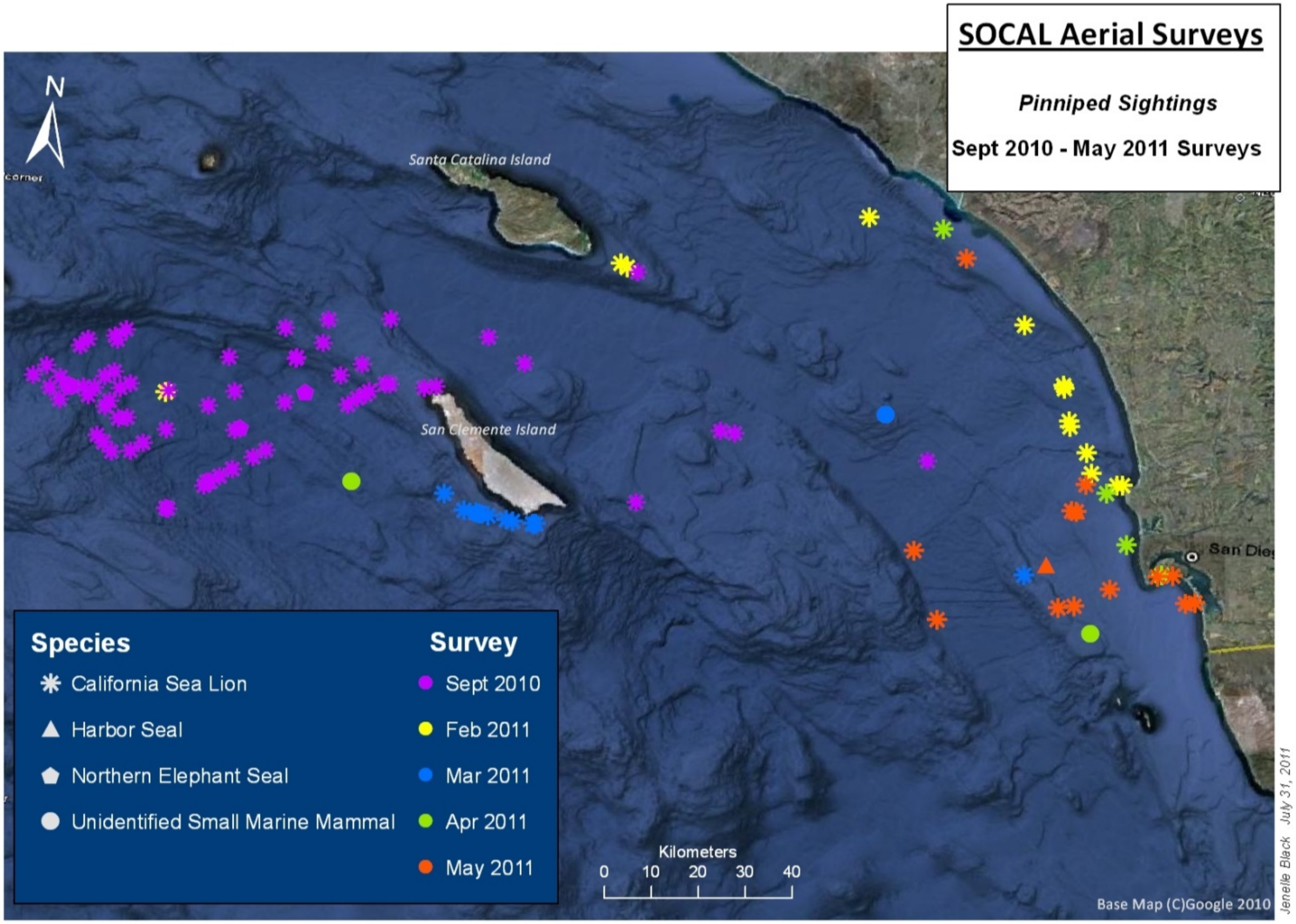

Figure 7. Pinniped sightings by species color-coded by month, during aerial surveys in SOCAL September 2010 and February – May 2011.

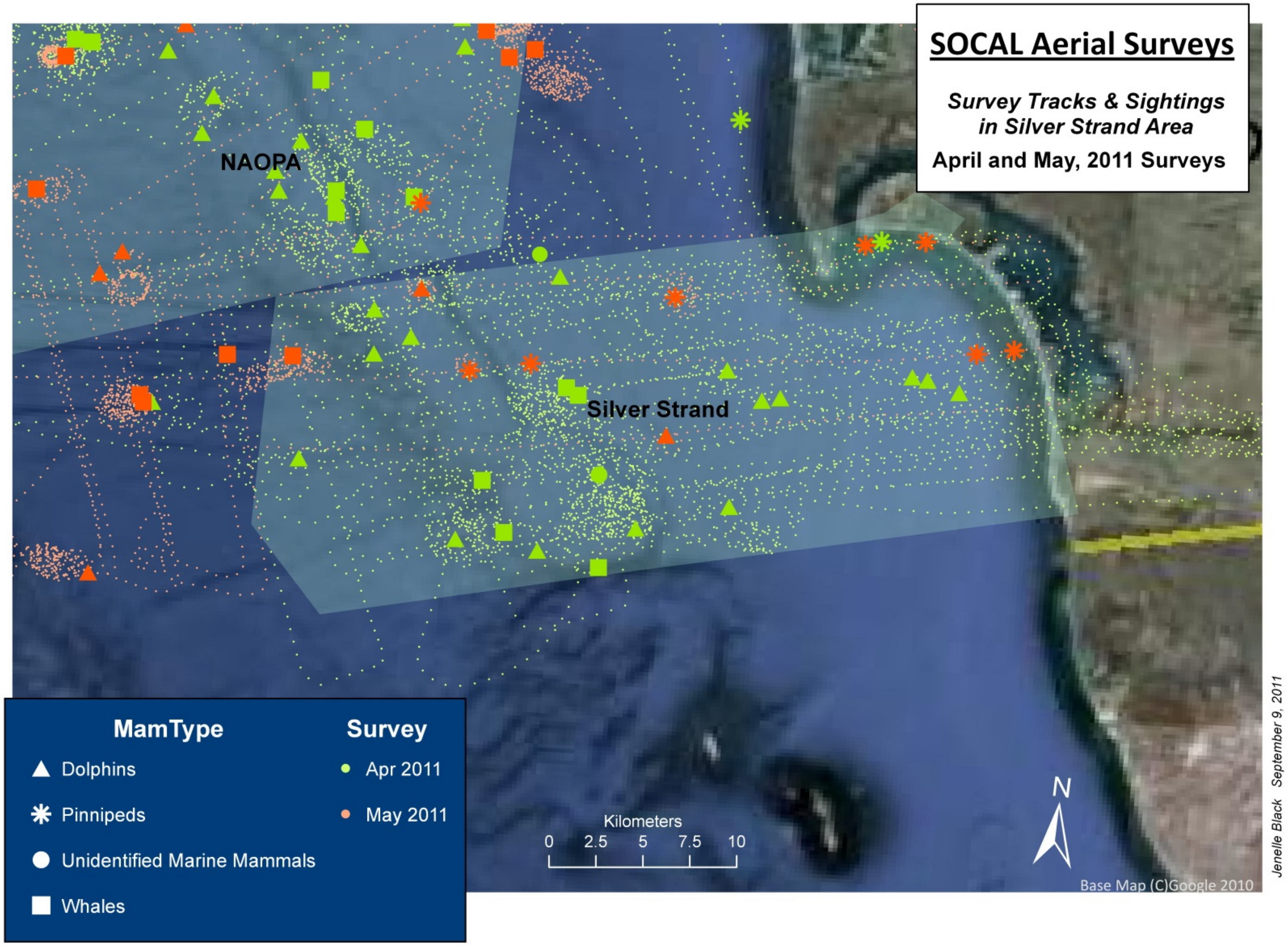

Figure 8. Aerial survey tracks and sightings in the Silver Strand area off San Diego flown in April and May 2011.

Appendix C. Tables

Table 1. Summary of Surveys September 2010 and February – May 2011.

Parameter	September	February	March	April	May	Total
Survey Dates	23-28 September 2010	14-19 February 2011	29 March - 3 April 2011	12-20 April 2011	9-14 May 2011	**5 surveys: September, February, March, April, May**
No. Days Flown	6	4	3	9	6	**28**
Platform Used	Partenavia P68-OBS	Partenavia P68-C	Partenavia P68-C	Twin Commander 685	Partenavia P68-C	**Partenavia or Twin Commander**
Major Training Exercise (MTE) Before, During or After Survey?	During, After	Before, During, After	none	none	During	**During, Before or After**
Total Flight Hr (Wheels up/down)	27.7	17.2	9.5	46.0	27.0	**127.4**
Total Observation Effort (km) *(excl. poor weather, over land)*	3918 km	3193 km	1865 km	10,976 km	4902 km	**24,854 km**
	(2116 nm)	(1724 nm)	(1007 nm)	(5926 nm)	(2647 nm)	**(13,420 nm)**
No. Groups Seen	252	83	71	136	81	**623**
Estimated No. Individuals	38,022	11,131	2,165	14,130	3,309	**68,757**
No. Dead Sightings	0	0	0	0	1	**1**
No. Species	9	8	8	11	11	**17**
No. Focal Groups Circled 5-9 min	6	2	4	0	0	**12**
No. Extended Focal Groups Circled >10 min	10	6	10	15	18	**59**
Longest Focal Follow Duration	45 min (Bryde's whale)	30 min (Gray whale)	22 min (Common dolphin sp.)	48 min (Fin whale)	67 min (Sperm whale)	**67 min (Sperm whale)**
No. Photos Taken	741	473	323	424	976	**2,937**
Estimated Usable Video (min)	143 min	79 min	95 min	239 min	299 min	**855 min**

Table 2. Unusual or noteworthy observations of marine mammals in the SOCAL aerial survey area September 2010 and February – May 2011.

Date	Time	Species	Group Size	Data Format Available for Review	Comments
9/24/2010	13:56:15	Bryde's whale, *Balaenoptera brydei/edeni*	1	field data sheet: observation record, photos	3 rostral ridges; Dr. Tom Jefferson confirmed photo as Bryde's whale
9/25/2010	11:55:00	Northern elephant seal, *Mirounga angustirostris*	11	field data sheet: observation record, photos	Stayed swimming at or near surface the whole time we circled
9/26/2010	12:00:00	Cuvier's beaked whale, *Ziphius cavirostris*	2	field data sheet: observation record	Blowing at surface and traveling slowly in opposite direction from the Cascadia Research Collective rigid-hulled inflatable research boat that was ~25 m away; D. Moretti group had been hearing them on hydrophone. Circled at 1 to 1.5 km radius to not interfere with the whales (well outside Snell's cone, at 304 m (1000 ft) altitude). Dr. B. Southall asked us to aid in sighting cetaceans for their ongoing SOCAL Behavioral Response Study (BRS), in particular helping to resight the Cuvier's beaked whales.
9/28/2010	9:41:30	Sei or Bryde's whale, *Balaenoptera borealis or B. brydei/edeni*	3	field data sheet: observation record, photos	Initially seen underwater then fluking up, circled for over 30 min while the whales sporadically lunge fed, 1 clear central rostral ridge and 2 small rostral ridges. Dr. Tom Jefferson examined photos but unclear if they were sei or Bryde's whales. No white on right side of jaw.
2/15/2011	8:45:10	Gray whale, *Eschrichtius robustus*	2	field data sheet: observation record; video, photos	A young (estimated under several days old) calf riding mother's back 3 times while mother rested/drifted. During apparent nursing, the calf faced mother at a 45° angle while mother held up her flukes.

Date	Time	Species	Group Size	Data Format Available for Review	Comments
2/17/2011	9:37:12	Dall's porpoise, *Phocoenoides dalli*	5	field data sheet: observation record	Small distinct black and white body coloration, small dolphin size of common dolphin but more robust and fatter.
4/1/2011	9:58:39	Risso's dolphins, *Grampus griseus*, northern right whale dolphins, *Lissodelphis borealis*	14 Risso's dolphins, 40 northern right whale dolphins	field data sheet: observation record; video, photos	Risso's dolphins and northern right whale dolphins appeared to forage and intersperse in same area. Both species occasionally sprinting followed by quick steep, brief dive and returning to the surface in the same area. Appeared to be foraging.
4/13/2011	15:23:10	*Dall's porpoise, *Phocoenoides dalli*	3	field data sheet: observation record	Identified as probable Dall's porpoise by the unique "rooster tailing" during fast travel and black and white contrasting color pattern and small body size.
4/14/2011	11:19:25	*Fin whales, *Balaenoptera physalus*	3	field data sheet: observation record, photos	Four fin whales seen for extended periods at the surface. Behaviors included animals rolling (ventral side at the surface) within 1 body length of each other (rarely observed or reported social behavior for fin whales)
4/19/2011	12:57:08	*Gray whale, *Eschrichtius robustus*	2	field data sheet: observation record	Gray whale calf observed interacting with mother. The calf moved on top of mother, apparently resting before and into nursing positions below mother. Team observed the calf moving under the mother's flukes from one side to the other in an apparent effort to return to a nursing position on the opposite side of mother.
5/9/2011	16:10:25	Whale shark, *Rhincodon typus*	1	field data sheet: vessel record	Seen while circling blue whale; brown body, seen swimming horizontally with tail like shark not like cetaceans. Smaller than a fin whale, maybe 10 m long. Head was much broader than latter half of body.

Date	Time	Species	Group Size	Data Format Available for Review	Comments
5/10/2011	12:06:26	Dead humpback whale, *Megaptera novaeangliae*	1	field data sheet: observation record, video, photos	19 nm off shore of Lindbergh Airport, one large (~ 4 m or 12-13 ft long) blue shark circling carcass. Many gulls on top of and circling carcass.
5/11/2011	15:59:54	Dead humpback whale, *Megaptera novaeangliae*	1	field data sheet: observation record, video, photos	Same humpback whale carcass seen previous day. Located about 4 nm west of Soledad, San Diego. 32 deg 48.17 N lat, 117 deg 19.22 W long. No sharks seen, some gulls, flesh hanging off chin into water, may be able to identify individual fluke patterns with N Pacific humpback catalog and animal's sex based on photos from plane.
5/14/2011	16:55:00	Risso's dolphins	14	field data sheet: video and observation record	Navy vessel seen ~2.5 nm away from group of Risso's. Risso's surface-active travel with a few individuals breaching. Such surface-active behavior by Risso's rarely observed during our previous SOCAL aerials surveys.
5/14/2011	10:36:14	Sperm whales, *Physeter macrocephalus;* Risso's dolphins, *Grampus griseus;* northern right whale dolphins*,* *Lissodelphis borealis*	20 sperm whales, 11 Risso's dolphins, 50 northern right whale dolphins	field data sheet: observation and behavior record, video, photos	Nursery group including 4 calves and no obvious large males; one calf very close to mother. Risso's dolphins swimming with and apparently harassing sperm whale nursery group by charging then fleeing repeatedly. Sperm whales seen opening their mouths and dropping their lower jaw on numerous occasions when Risso's dolphins swim close by the mouth of the sperm whale. Northern right whale dolphins interspersed as well.
4/1/2011-5/14/2011		Ocean sunfish, *mola mola*	n=2 during March survey, 44 in April survey, 14 in May survey	field data sheet: vessel record	Ocean sunfish counts and declination angles were taken during the March survey and continued through the May survey.

*Note: unable to get quality video and photos through the closed window of the Twin Commander. Open windows were not available to the research team.

Table 3. Numbers of individuals and groups by species seen during SOCAL marine species monitoring surveys, September 2010 and February - May 2011. Note: In descending order, except for Short and Long-Beaked Common Dolphins.

Common Name	Scientific Name	September		February		March		April		May		Total	
		# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv
Common Dolphin sp.	*Delphinus* sp.	113	32,297	20	4,860	15	713	35	5,432	9	1,845	**192**	**45,147**
Short-beaked Common Dolphin	*Delphinus delphis*	5	1,015	8	3,765	1	40	5	4,795	3	1,115	**22**	**10,730**
Long-beaked Common Dolphin	*Delphinus capensis*	8	874	3	752	3	580	5	1,900	1	50	**20**	**4,156**
California Sea Lion	*Zalophus californianus*	72	213	13	33	10	13	4	6	13	40	**112**	**305**
Unidentified Dolphin	Delphinidae sp.	31	3,459	12	1,399	5	449	17	723	7	501	**72**	**6,531**
Risso's Dolphin	*Grampus griseus*	6	76	8	178	15	232	28	1,069	9	100	**66**	**1,655**
Bottlenose Dolphin	*Tursiops truncatus*	5	49	8	127	5	38	7	146	6	127	**31**	**487**
Fin Whale	*Balaenoptera physalus*	0	0	3	4	0	0	12	20	8	11	**23**	**35**
Blue Whale	*Balaenoptera musculus*	0	0	0	0	0	0	3	4	12	15	**15**	**19**
Gray Whale	*Eschrichtius robustus*	0	0	5	6	5	14	4	7	0	0	**14**	**27**
Unidentified Baleen Whale	*Balaenoptera* sp.	2	2	1	1	0	0	1	1	4	5	**8**	**9**
Northern Right Whale Dolphin	*Lissodelphis borealis*	0	0	0	0	4	55	2	10	1	50	**7**	**115**
Minke Whale	*Balaenoptera acutorostrata*	1	3	1	1	2	3	2	3	1	1	**7**	**11**

Common Name	Scientific Name	September		February		March		April		May		Total	
		# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv
Humpback Whale	*Megaptera novaeangliae*	0	0	0	0	1	2	2	2	2	2	**5**	**6**
Unidentified Whale	Cetacea	0	0	0	0	1	3	3	4	0	0	**4**	**7**
Unidentified Small Marine Mammal	Cetacea or Pinnipedia	1	1	0	0	1	1	2	2	0	0	**4**	**4**
Northern Elephant Seal	*Mirounga angustirostris*	3	22	0	0	0	0	0	0	0	0	**3**	**22**
Unidentified Medium Whale	Cetacea	0	0	0	0	1	1	1	1	1	4	**3**	**6**
Harbor Seal	*Phoca vitulina*	0	0	0	0	0	0	0	0	2	4	**2**	**4**
Dall's Porpoise	*Phocoenoides dalli*	0	0	1	5	0	0	1	3	0	0	**2**	**8**
Unidentified Small Dolphin	Delphinidae sp.	0	0	0	0	1	20	0	0	0	0	**1**	**20**
Unidentified Medium Marine Mammal	Cetacea or Pinnipedia	1	1	0	0	0	0	0	0	0	0	**1**	**1**
Sperm Whale	*Physeter macrocephalus*	0	0	0	0	0	0	0	0	1	20	**1**	**20**
Unidentified Marine Mammal	Cetacea	1	4	0	0	0	0	0	0	0	0	**1**	**4**
Sei/Bryde's Whale	*Balaenoptera borealis or edeni/brydei*	1	3	0	0	0	0	0	0	0	0	**1**	**3**
Cuvier's Beaked Whale	*Ziphius cavirostris*	1	2	0	0	0	0	0	0	0	0	**1**	**2**
Fin/Sei/Bryde's Whale	*Balaenoptera* sp.	0	0	0	0	1	1	0	0	0	0	**1**	**1**

Common Name	Scientific Name	September		February		March		April		May		Total	
		# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv
Bryde's Whale	*Balaenoptera brydei/edeni*	1	1	0	0	0	0	0	0	0	0	**1**	**1**
Unidentified Large Whale	Cetacea	0	0	0	0	0	0	1	1	0	0	**1**	**1**
Unidentified Small Whale	Cetacea	0	0	0	0	0	0	1	1	0	0	**1**	**1**
Total		**252**	**38,022**	**83**	**11,131**	**71**	**2,165**	**136**	**14,130**	**81**	**3,309**	**623**	**68,757**

Table 4. Locations, species descriptions and group sizes for all sightings on September 2010 and February-May 2011 SOCAL aerial surveys.

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011					
09/23/2010 15:10:53	Long-Beaked Common Dolphin	*Delphinus capensis*	25	32.76800	-117.57533
09/23/2010 15:28:54	Common Dolphin sp.	undifferentiated *Delphinus*	6	32.92483	-117.40550
09/23/2010 15:54:04	Bottlenose Dolphin	*Tursiops truncatus*	1	32.79050	-118.01200
09/23/2010 16:07:24	Short-Beaked Common Dolphin	*Delphinus delphis*	15	32.81333	-118.23150
09/23/2010 16:08:24	California Sea Lion	*Zalophus californianus*	1	32.81683	-118.21700
09/23/2010 16:16:14	Long-Beaked Common Dolphin	*Delphinus capensis*	60	32.87733	-118.24733
09/23/2010 16:29:54	Common Dolphin sp.	undifferentiated *Delphinus*	700	32.90483	-118.11367
09/23/2010 16:54:14	Common Dolphin sp.	undifferentiated *Delphinus*	600	33.01700	-117.32650
09/23/2010 16:56:54	Bottlenose Dolphin	*Tursiops truncatus*	2	32.95150	-117.30950
09/23/2010 16:59:04	Common Dolphin sp.	undifferentiated *Delphinus*	80	32.89967	-117.31600
09/23/2010 17:09:15	Common Dolphin sp.	undifferentiated *Delphinus*	200	32.65517	-117.30383
09/23/2010 17:09:55	Common Dolphin sp.	undifferentiated *Delphinus*	300	32.64183	-117.29133
09/23/2010 17:14:55	Bottlenose Dolphin	*Tursiops truncatus*	3	32.55350	-117.25383
09/23/2010 17:21:15	Common Dolphin sp.	undifferentiated *Delphinus*	315	32.70167	-117.34133
09/23/2010 17:24:25	Common Dolphin sp.	undifferentiated *Delphinus*	40	32.78700	-117.36367
09/24/2010 12:02:38	Unidentified Medium Marine Mammal	unidentified marine mammal	1	33.00333	-117.99567
09/24/2010 12:07:30	Unidentified Dolphin	unidentified Delphinidae	250	33.04517	-118.20767
09/24/2010 12:08:57	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.05783	-118.27133
09/24/2010 12:09:32	Unidentified Dolphin	unidentified Delphinidae	1000	33.06233	-118.29717
09/24/2010 12:16:55	Bottlenose Dolphin	*Tursiops truncatus*	25	33.12833	-118.62200
09/24/2010 12:21:05	California Sea Lion	*Zalophus californianus*	1	33.16700	-118.80450
09/24/2010 12:27:29	Short-Beaked Common Dolphin	*Delphinus delphis*	375	33.08733	-119.00617
09/24/2010 12:35:59	Unidentified Marine Mammal	unidentified marine mammal	4	33.03217	-119.11017
09/24/2010 12:36:42	California Sea Lion	*Zalophus californianus*	2	33.02883	-119.11800
09/24/2010 12:37:36	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.01800	-119.13567
09/24/2010 12:38:52	Common Dolphin sp.	undifferentiated *Delphinus*	70	32.99900	-119.16950

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/24/2010 12:39:22	Common Dolphin sp.	undifferentiated *Delphinus*	125	32.99150	-119.18300
09/24/2010 12:40:15	California Sea Lion	*Zalophus californianus*	30	32.97850	-119.20633
09/24/2010 12:40:25	Unidentified Dolphin	unidentified Delphinidae	4	32.97850	-119.20633
09/24/2010 12:42:14	California Sea Lion	*Zalophus californianus*	4	32.94633	-119.24717
09/24/2010 12:42:53	California Sea Lion	*Zalophus californianus*	1	32.93217	-119.23567
09/24/2010 12:43:00	California Sea Lion	*Zalophus californianus*	3	32.93217	-119.23567
09/24/2010 12:43:30	California Sea Lion	*Zalophus californianus*	1	32.93217	-119.23567
09/24/2010 12:43:44	California Sea Lion	*Zalophus californianus*	1	32.91367	-119.22017
09/24/2010 12:44:16	Common Dolphin sp.	undifferentiated *Delphinus*	*	32.90200	-119.21050
09/24/2010 12:48:38	California Sea Lion	*Zalophus californianus*	1	32.91600	-119.18317
09/24/2010 12:49:36	California Sea Lion	*Zalophus californianus*	2	32.93133	-119.15867
09/24/2010 12:50:05	California Sea Lion	*Zalophus californianus*	2	32.93133	-119.15867
09/24/2010 12:50:53	Unidentified Marine Mammal	unidentified marine mammal	5	32.95200	-119.12367
09/24/2010 12:54:06	Northern Elephant Seal	*Mirounga angustirostris*	5	32.96733	-119.12433
09/24/2010 13:06:17	California Sea Lion	*Zalophus californianus*	1	33.00250	-119.03433
09/24/2010 13:08:01	California Sea Lion	*Zalophus californianus*	1	33.02967	-118.98367
09/24/2010 13:11:57	California Sea Lion	*Zalophus californianus*	1	33.09317	-118.86650
09/24/2010 13:13:52	California Sea Lion	*Zalophus californianus*	2	33.12267	-118.81467
09/24/2010 13:21:23	California Sea Lion	*Zalophus californianus*	1	33.08183	-118.74050
09/24/2010 13:22:51	California Sea Lion	*Zalophus californianus*	2	33.06067	-118.78117
09/24/2010 13:25:15	Common Dolphin sp.	undifferentiated *Delphinus*	2	33.02567	-118.84583
09/24/2010 13:30:44	California Sea Lion	*Zalophus californianus*	25	33.00817	-118.88767
09/24/2010 13:34:12	California Sea Lion	*Zalophus californianus*	4	32.95600	-118.98417
09/24/2010 13:42:05	Unidentified Baleen Whale	unidentified balaenopterid	1	32.83850	-119.14900
09/24/2010 13:48:43	California Sea Lion	*Zalophus californianus*	1	32.80600	-119.11600
09/24/2010 13:48:50	California Sea Lion	*Zalophus californianus*	1	32.80600	-119.11600
09/24/2010 13:51:19	California Sea Lion	*Zalophus californianus*	2	32.84883	-119.04400
09/24/2010 13:51:50	California Sea Lion	*Zalophus californianus*	1	32.85667	-119.03067

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/24/2010 13:52:10	California Sea Lion	*Zalophus californianus*	1	32.85667	-119.03067
09/24/2010 13:52:29	California Sea Lion	*Zalophus californianus*	1	32.86683	-119.01317
09/24/2010 13:52:42	California Sea Lion	*Zalophus californianus*	1	32.86683	-119.01317
09/24/2010 13:53:17	California Sea Lion	*Zalophus californianus*	2	32.86683	-119.01317
09/24/2010 13:53:22	California Sea Lion	*Zalophus californianus*	2	32.88083	-118.98800
09/24/2010 13:54:47	California Sea Lion	*Zalophus californianus*	1	32.90367	-118.94850
09/24/2010 13:55:04	California Sea Lion	*Zalophus californianus*	2	32.90367	-118.94850
09/24/2010 13:55:38	California Sea Lion	*Zalophus californianus*	4	32.91700	-118.92500
09/24/2010 13:56:15	Bryde's Whale	*Balaenoptera brydei/edeni*	1	32.91700	-118.92500
09/24/2010 14:02:33	California Sea Lion	*Zalophus californianus*	1	33.00467	-118.76850
09/24/2010 14:03:17	California Sea Lion	*Zalophus californianus*	1	33.01617	-118.74900
09/24/2010 14:03:46	California Sea Lion	*Zalophus californianus*	1	33.01617	-118.74900
09/24/2010 14:05:11	California Sea Lion	*Zalophus californianus*	1	33.04450	-118.69550
09/24/2010 14:05:25	California Sea Lion	*Zalophus californianus*	1	33.04417	-118.68733
09/24/2010 14:07:18	California Sea Lion	*Zalophus californianus*	1	33.03617	-118.62200
09/24/2010 14:07:56	California Sea Lion	*Zalophus californianus*	1	33.03617	-118.62200
09/24/2010 14:16:14	Long-Beaked Common Dolphin	*Delphinus capensis*	250	32.99217	-118.31783
09/24/2010 14:22:42	Risso's Dolphin	*Grampus griseus*	2	32.99467	-118.27783
09/24/2010 14:22:44	Unidentified Dolphin	unidentified Delphinidae	15	32.99467	-118.27783
09/24/2010 14:27:05	Common Dolphin sp.	undifferentiated *Delphinus*	300	32.97267	-118.19200
09/24/2010 14:30:00	Unidentified Dolphin	unidentified Delphinidae	5	32.95833	-118.08700
09/24/2010 14:30:56	California Sea Lion	*Zalophus californianus*	1	32.95367	-118.05467
09/24/2010 14:31:42	California Sea Lion	*Zalophus californianus*	1	32.95367	-118.05467
09/24/2010 14:32:26	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.94750	-118.00283
09/24/2010 14:33:08	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.94350	-117.97783
09/24/2010 14:37:03	Common Dolphin sp.	undifferentiated *Delphinus*	50	32.92250	-117.83400
09/24/2010 14:37:53	Common Dolphin sp.	undifferentiated *Delphinus*	200	32.91817	-117.80817
09/24/2010 14:38:50	Common Dolphin sp.	undifferentiated *Delphinus*	6	32.91383	-117.77783

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/24/2010 14:42:18	California Sea Lion	*Zalophus californianus*	1	32.89667	-117.65817
09/24/2010 16:10:58	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.91200	-117.34750
09/24/2010 16:15:58	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.02083	-117.48933
09/24/2010 16:17:58	Long-Beaked Common Dolphin	*Delphinus capensis*	*	33.03483	-117.49433
09/24/2010 16:20:58	Long-Beaked Common Dolphin	*Delphinus capensis*	30	33.06867	-117.54217
09/24/2010 16:21:58	Long-Beaked Common Dolphin	*Delphinus capensis*	200	33.08400	-117.56750
09/24/2010 16:36:58	Long-Beaked Common Dolphin	*Delphinus capensis*	300	33.35767	-117.91533
09/24/2010 16:58:58	Common Dolphin sp.	undifferentiated *Delphinus*	40	33.41233	-117.86100
09/24/2010 17:04:58	Unidentified Dolphin	unidentified Delphinidae	150	33.38367	-117.80717
09/24/2010 17:08:58	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.30950	-117.68300
09/24/2010 17:11:58	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.30233	-117.65900
09/24/2010 17:12:58	Long-Beaked Common Dolphin	*Delphinus capensis*	9	33.28483	-117.62817
09/24/2010 17:17:58	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.24483	-117.57750
09/24/2010 17:20:58	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.18417	-117.49083
09/24/2010 17:24:58	Common Dolphin sp.	undifferentiated *Delphinus*	70	33.13867	-117.45267
09/25/2010 10:32:58	Common Dolphin sp.	undifferentiated *Delphinus*	700	32.94500	-117.67850
09/25/2010 10:33:01	Risso's Dolphin	*Grampus griseus*	10	32.94500	-117.67850
09/25/2010 10:38:58	Unidentified Dolphin	unidentified Delphinidae	19	32.98733	-117.89083
09/25/2010 10:44:48	Common Dolphin sp.	undifferentiated *Delphinus*	20	33.02883	-118.09717
09/25/2010 10:53:58	Unidentified Dolphin	unidentified Delphinidae	75	33.09350	-118.42567
09/25/2010 11:00:58	Common Dolphin sp.	undifferentiated *Delphinus*	350	33.14233	-118.67633
09/25/2010 11:06:58	California Sea Lion	*Zalophus californianus*	1	33.15267	-118.88733
09/25/2010 11:07:08	Common Dolphin sp.	undifferentiated *Delphinus*	1100	33.15267	-118.88733
09/25/2010 11:08:58	Unidentified Dolphin	unidentified Delphinidae	400	33.14433	-118.93867
09/25/2010 11:17:58	Common Dolphin sp.	undifferentiated *Delphinus*	15	33.05017	-119.07817
09/25/2010 11:37:58	California Sea Lion	*Zalophus californianus*	1	33.09500	-118.86500
09/25/2010 11:39:58	Short-Beaked Common Dolphin	*Delphinus delphis*	100	33.12667	-118.80767
09/25/2010 11:46:58	Common Dolphin sp.	undifferentiated *Delphinus*	400	33.12600	-118.69750

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/25/2010 11:54:58	Northern Elephant Seal	*Mirounga angustirostris*	11	33.02967	-118.84833
09/25/2010 12:02:58	Northern Elephant Seal	*Mirounga angustirostris*	6	32.96183	-118.97300
09/25/2010 12:16:58	California Sea Lion	*Zalophus californianus*	35	32.85617	-119.03817
09/25/2010 12:29:58	California Sea Lion	*Zalophus californianus*	2	33.02450	-118.73500
09/25/2010 12:32:58	Common Dolphin sp.	undifferentiated *Delphinus*	1200	33.05167	-118.62867
09/25/2010 12:40:58	Common Dolphin sp.	undifferentiated *Delphinus*	1600	33.09733	-118.33067
09/25/2010 12:51:58	Common Dolphin sp.	undifferentiated *Delphinus*	150	33.15500	-118.08233
09/25/2010 13:01:58	Common Dolphin sp.	undifferentiated *Delphinus*	110	33.19183	-117.92133
09/25/2010 13:02:08	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.19183	-117.92133
09/25/2010 13:05:58	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.20100	-117.88233
09/25/2010 13:21:58	Short-Beaked Common Dolphin	*Delphinus delphis*	75	33.06433	-117.38400
09/25/2010 13:23:58	Common Dolphin sp.	undifferentiated *Delphinus*	200	33.06150	-117.36000
09/25/2010 13:27:58	Unidentified Dolphin	unidentified Delphinidae	40	32.96600	-117.31150
09/25/2010 13:28:58	Unidentified Dolphin	unidentified Delphinidae	8	32.93417	-117.30617
09/26/2010 10:46:10	Unidentified Dolphin	unidentified Delphinidae	1	32.94500	-117.55033
09/26/2010 10:50:30	Unidentified Dolphin	unidentified Delphinidae	30	32.97000	-117.72867
09/26/2010 10:52:20	Common Dolphin sp.	undifferentiated *Delphinus*	20	32.98167	-117.80300
09/26/2010 10:53:30	Common Dolphin sp.	undifferentiated *Delphinus*	40	32.99150	-117.84933
09/26/2010 10:55:20	Common Dolphin sp.	undifferentiated *Delphinus*	125	33.00550	-117.92333
09/26/2010 11:02:50	Common Dolphin sp.	undifferentiated *Delphinus*	200	33.06417	-118.22067
09/26/2010 11:04:50	Unidentified Dolphin	unidentified Delphinidae	20	33.07800	-118.30100
09/26/2010 11:09:10	Unidentified Dolphin	unidentified Delphinidae	2	33.10983	-118.47583
09/26/2010 11:11:00	Common Dolphin sp.	undifferentiated *Delphinus*	200	33.12467	-118.54967
09/26/2010 11:11:20	Common Dolphin sp.	undifferentiated *Delphinus*	60	33.12683	-118.56333
09/26/2010 11:12:50	Common Dolphin sp.	undifferentiated *Delphinus*	400	33.13800	-118.62500
09/26/2010 12:00:00	Cuvier's Beaked Whale	*Ziphius cavirostris*	2	32.84183	-119.15033
09/26/2010 12:43:10	California Sea Lion	*Zalophus californianus*	1	32.97950	-119.18967
09/26/2010 12:58:10	Unidentified Dolphin	unidentified Delphinidae	15	32.94583	-119.25417

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/26/2010 13:13:30	Common Dolphin sp.	undifferentiated *Delphinus*	1000	33.17500	-118.84650
09/26/2010 13:43:10	California Sea Lion	*Zalophus californianus*	2	33.16850	-118.68533
09/26/2010 13:47:40	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.11733	-118.48750
09/26/2010 13:59:00	Unidentified Dolphin	unidentified Delphinidae	24	33.01717	-117.96950
09/26/2010 14:01:50	Unidentified Dolphin	unidentified Delphinidae	150	32.97650	-117.84217
09/26/2010 14:02:30	Common Dolphin sp.	undifferentiated *Delphinus*	50	32.96667	-117.81217
09/26/2010 14:09:10	Common Dolphin sp.	undifferentiated *Delphinus*	250	32.88683	-117.50433
09/26/2010 14:10:10	Common Dolphin sp.	undifferentiated *Delphinus*	550	32.87683	-117.45817
09/26/2010 15:34:53	Unidentified Dolphin	unidentified Delphinidae	70	33.03067	-117.43667
09/26/2010 15:35:53	Unidentified Dolphin	unidentified Delphinidae	4	33.05650	-117.45850
09/26/2010 15:37:53	Common Dolphin sp.	undifferentiated *Delphinus*	190	33.09633	-117.51383
09/26/2010 15:46:53	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.32067	-117.69717
09/26/2010 15:48:13	Common Dolphin sp.	undifferentiated *Delphinus*	90	33.35700	-117.72233
09/26/2010 16:00:53	Short-Beaked Common Dolphin	*Delphinus delphis*	450	33.37400	-118.03250
09/26/2010 16:10:33	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.41467	-118.01467
09/26/2010 16:19:23	Unidentified Dolphin	unidentified Delphinidae	125	33.26750	-118.30267
09/26/2010 16:53:33	Common Dolphin sp.	undifferentiated *Delphinus*	400	33.12900	-117.42150
09/27/2010 09:44:54	Unidentified Dolphin	unidentified Delphinidae	50	32.89650	-117.32667
09/27/2010 09:54:54	Common Dolphin sp.	undifferentiated *Delphinus*	2100	32.95900	-117.78850
09/27/2010 09:55:00	Common Dolphin sp.	undifferentiated *Delphinus*	550	32.95900	-117.78850
09/27/2010 09:55:54	Common Dolphin sp.	undifferentiated *Delphinus*	200	32.96633	-117.83483
09/27/2010 09:56:54	Common Dolphin sp.	undifferentiated *Delphinus*	150	32.97383	-117.88083
09/27/2010 10:05:24	Unidentified Dolphin	unidentified Delphinidae	60	33.06967	-118.25783
09/27/2010 10:06:24	Common Dolphin sp.	undifferentiated *Delphinus*	2200	33.09117	-118.29467
09/27/2010 10:11:04	California Sea Lion	*Zalophus californianus*	2	33.13433	-118.49767
09/27/2010 10:17:14	Common Dolphin sp.	undifferentiated *Delphinus*	250	33.17733	-118.75567
09/27/2010 10:18:04	Common Dolphin sp.	undifferentiated *Delphinus*	200	33.18233	-118.78533
09/27/2010 10:19:14	Common Dolphin sp.	undifferentiated *Delphinus*	25	33.18017	-118.82883

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/27/2010 10:24:44	California Sea Lion	*Zalophus californianus*	1	33.09483	-118.99450
09/27/2010 10:25:44	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.07867	-119.02500
09/27/2010 10:46:35	California Sea Lion	*Zalophus californianus*	1	33.12850	-119.20767
09/27/2010 10:46:55	California Sea Lion	*Zalophus californianus*	1	33.13700	-119.21317
09/27/2010 10:48:05	Risso's Dolphin	*Grampus griseus*	30	33.16500	-119.22767
09/27/2010 11:15:35	California Sea Lion	*Zalophus californianus*	2	33.06183	-119.36883
09/27/2010 11:16:45	California Sea Lion	*Zalophus californianus*	2	33.08083	-119.34317
09/27/2010 11:23:25	Unidentified Small Marine Mammal	unidentified marine mammal	1	33.04083	-119.29950
09/27/2010 11:27:25	California Sea Lion	*Zalophus californianus*	1	33.03900	-119.27400
09/27/2010 11:29:56	California Sea Lion	*Zalophus californianus*	1	33.06883	-119.21467
09/27/2010 11:35:36	California Sea Lion	*Zalophus californianus*	1	33.00183	-119.23300
09/27/2010 11:36:06	California Sea Lion	*Zalophus californianus*	1	33.01183	-119.22383
09/27/2010 11:37:16	California Sea Lion	*Zalophus californianus*	1	33.03617	-119.20417
09/27/2010 11:38:06	California Sea Lion	*Zalophus californianus*	1	33.04567	-119.18367
09/27/2010 11:50:16	California Sea Lion	*Zalophus californianus*	1	33.05833	-119.23300
09/27/2010 11:51:16	California Sea Lion	*Zalophus californianus*	2	33.03733	-119.25267
09/27/2010 11:51:56	California Sea Lion	*Zalophus californianus*	1	33.02300	-119.26450
09/27/2010 11:55:06	Minke Whale	*Balaenoptera acutorostrata*	3	33.01867	-119.32683
09/27/2010 11:59:56	California Sea Lion	*Zalophus californianus*	1	33.01550	-119.31867
09/27/2010 12:10:56	California Sea Lion	*Zalophus californianus*	1	33.05767	-119.31733
09/27/2010 12:11:56	California Sea Lion	*Zalophus californianus*	5	33.03700	-119.33817
09/27/2010 12:16:16	California Sea Lion	*Zalophus californianus*	2	33.11800	-119.27933
09/27/2010 12:16:56	California Sea Lion	*Zalophus californianus*	1	33.13000	-119.26433
09/27/2010 12:19:26	California Sea Lion	*Zalophus californianus*	1	33.14867	-119.19183
09/27/2010 12:21:06	Risso's Dolphin	*Grampus griseus*	8	33.14800	-119.12850
09/27/2010 12:45:06	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.16267	-118.90000
09/27/2010 12:56:46	California Sea Lion	*Zalophus californianus*	4	33.08283	-118.42917
09/27/2010 13:00:16	Common Dolphin sp.	undifferentiated *Delphinus*	350	33.10783	-118.28800

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/27/2010 13:00:56	Common Dolphin sp.	undifferentiated *Delphinus*	40	33.11133	-118.26017
09/27/2010 13:04:36	Common Dolphin sp.	undifferentiated *Delphinus*	605	33.14500	-118.10917
09/27/2010 13:11:36	Common Dolphin sp.	undifferentiated *Delphinus*	180	33.20033	-117.81383
09/27/2010 13:13:06	Common Dolphin sp.	undifferentiated *Delphinus*	40	33.21533	-117.75017
09/27/2010 13:16:36	Common Dolphin sp.	undifferentiated *Delphinus*	55	33.25300	-117.59717
09/27/2010 13:17:46	Common Dolphin sp.	undifferentiated *Delphinus*	450	33.24783	-117.54717
09/27/2010 13:21:56	Unidentified Dolphin	unidentified Delphinidae	100	33.13217	-117.43200
09/27/2010 13:23:56	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.07050	-117.38967
09/27/2010 13:24:56	Common Dolphin sp.	undifferentiated *Delphinus*	850	33.03883	-117.36917
09/27/2010 13:26:56	Unidentified Dolphin	unidentified Delphinidae	250	32.97300	-117.33367
09/27/2010 13:28:16	Common Dolphin sp.	undifferentiated *Delphinus*	750	32.92783	-117.31317
09/27/2010 14:46:43	Common Dolphin sp.	undifferentiated *Delphinus*	650	32.90500	-117.28867
09/27/2010 14:48:13	Common Dolphin sp.	undifferentiated *Delphinus*	125	32.95350	-117.31917
09/27/2010 14:50:03	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.00717	-117.35300
09/27/2010 14:50:33	Common Dolphin sp.	undifferentiated *Delphinus*	350	33.02117	-117.36250
09/27/2010 14:51:23	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.04400	-117.37800
09/27/2010 14:52:43	Common Dolphin sp.	undifferentiated *Delphinus*	60	33.05033	-117.41783
09/27/2010 14:57:13	Common Dolphin sp.	undifferentiated *Delphinus*	12	33.01917	-117.56033
09/27/2010 14:57:23	Common Dolphin sp.	undifferentiated *Delphinus*	275	33.01800	-117.56600
09/27/2010 15:01:03	Common Dolphin sp.	undifferentiated *Delphinus*	40	33.01167	-117.60967
09/27/2010 15:01:43	Common Dolphin sp.	undifferentiated *Delphinus*	90	33.00683	-117.63067
09/27/2010 15:02:23	Common Dolphin sp.	undifferentiated *Delphinus*	135	33.00150	-117.65267
09/27/2010 15:17:13	Common Dolphin sp.	undifferentiated *Delphinus*	30	32.98617	-117.71750
09/27/2010 15:19:33	Common Dolphin sp.	undifferentiated *Delphinus*	50	32.97367	-117.78567
09/27/2010 15:27:43	Common Dolphin sp.	undifferentiated *Delphinus*	1299	32.92567	-118.02500
09/27/2010 15:27:53	Common Dolphin sp.	undifferentiated *Delphinus*	70	32.92567	-118.02500
09/27/2010 16:15:53	Unidentified Dolphin	unidentified Delphinidae	25	32.98367	-117.55150
09/27/2010 16:19:43	Common Dolphin sp.	undifferentiated *Delphinus*	505	33.01050	-117.42667

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/27/2010 16:24:23	Common Dolphin sp.	undifferentiated *Delphinus*	450	32.93050	-117.31817
09/28/2010 08:48:59	Unidentified Dolphin	unidentified Delphinidae	1	32.88267	-117.29833
09/28/2010 08:54:59	Unidentified Baleen Whale	unidentified balaenopterid	1	33.03300	-117.44250
09/28/2010 08:58:19	Common Dolphin sp.	undifferentiated *Delphinus*	600	33.04167	-117.44633
09/28/2010 09:32:49	Common Dolphin sp.	undifferentiated *Delphinus*	150	33.10050	-117.51933
09/28/2010 09:41:29	Sei/Bryde's Whale	*Balaenoptera borealis/edeni/brydei*	3	33.27733	-117.79600
09/28/2010 09:59:59	Unidentified Dolphin	unidentified Delphinidae	500	33.31367	-117.79800
09/28/2010 10:27:39	Unidentified Dolphin	unidentified Delphinidae	8	33.42817	-117.99683
09/28/2010 11:58:51	Unidentified Dolphin	unidentified Delphinidae	8	34.16033	-119.32867
09/28/2010 12:20:31	Common Dolphin sp.	undifferentiated *Delphinus*	100	34.03800	-119.15983
09/28/2010 12:47:11	Common Dolphin sp.	undifferentiated *Delphinus*	10	33.62367	-118.26050
09/28/2010 12:53:11	Common Dolphin sp.	undifferentiated *Delphinus*	80	33.54317	-118.03283
09/28/2010 12:55:01	Common Dolphin sp.	undifferentiated *Delphinus*	400	33.52050	-117.96150
09/28/2010 13:17:51	Unidentified Dolphin	unidentified Delphinidae	50	33.44667	-117.95000
09/28/2010 13:19:21	Common Dolphin sp.	undifferentiated *Delphinus*	15	33.43733	-118.00117
09/28/2010 13:20:41	Risso's Dolphin	*Grampus griseus*	25	33.42900	-118.04533
09/28/2010 13:47:11	Common Dolphin sp.	undifferentiated *Delphinus*	75	33.41967	-118.10850
09/28/2010 13:50:11	Risso's Dolphin	Grampus griseus	1	33.40000	-118.20967
09/28/2010 13:56:01	Common Dolphin sp.	undifferentiated *Delphinus*	15	33.31833	-118.22617
09/28/2010 13:58:01	Common Dolphin sp.	undifferentiated *Delphinus*	25	33.29150	-118.28633
09/28/2010 14:01:51	Common Dolphin sp.	undifferentiated *Delphinus*	200	33.24867	-118.40417
09/28/2010 14:14:21	Common Dolphin sp.	undifferentiated Delphinus	60	33.22900	-118.36750
09/28/2010 14:17:51	Common Dolphin sp.	undifferentiated Delphinus	100	33.25600	-118.25033
09/28/2010 14:19:21	Bottlenose Dolphin	Tursiops truncatus	18	33.26700	-118.20183
09/28/2010 14:26:21	California Sea Lion	undifferentiated *Delphinus*	40	33.25917	-118.21317
09/28/2010 14:43:21	Common Dolphin sp.	undifferentiated *Delphinus*	12	33.34167	-117.85417
09/28/2010 14:46:41	Common Dolphin sp.	undifferentiated *Delphinus*	42	33.36467	-117.73950
09/28/2010 14:54:11	Common Dolphin sp.	undifferentiated *Delphinus*	750	33.24867	-117.54183

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
SEPTEMBER SURVEY: 23-28 September 2011 (continued)					
09/28/2010 15:06:21	Common Dolphin sp.	undifferentiated Delphinus	5	32.93133	-117.31617
09/28/2010 15:07:31	Common Dolphin sp.	undifferentiated Delphinus	550	32.89900	-117.29883
FEBRUARY SURVEY: 14-19 FEBRUARY 2011					
2/14/2011 13:21:54	Bottlenose Dolphin	*Tursiops truncatus*	10	32.85983	-117.25833
2/14/2011 13:22:24	Bottlenose Dolphin	*Tursiops truncatus*	25	32.876	-117.26567
2/14/2011 13:50:04	Bottlenose Dolphin	*Tursiops truncatus*	6	33.01383	-117.36517
2/14/2011 14:03:44	Unidentified Dolphin	unidentified Delphinidae	1	32.97067	-117.37217
2/14/2011 14:03:44	Common Dolphin sp.	undifferentiated *Delphinus*	75	32.97067	-117.37217
2/14/2011 13:35:54	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.03633	-117.34383
2/14/2011 15:56:09	Unidentified Dolphin	unidentified Delphinidae	6	33.10067	-117.382
2/14/2011 16:08:59	Bottlenose Dolphin	*Tursiops truncatus*	1	32.8345	-117.29633
2/14/2011 16:27:29	Long-Beaked Common Dolphin	*Delphinus capensis*	30	32.73883	-117.30333
2/15/2011 8:45:08	Gray Whale	*Eschrichtius robustus*	2	32.8215	-117.31133
2/15/2011 9:25:19	Unidentified Dolphin	unidentified Delphinidae	1	32.67333	-117.61
2/15/2011 9:33:09	Short-Beaked Common Dolphin	*Delphinus delphis*	25	32.66967	-117.6405
2/15/2011 9:54:29	Short-Beaked Common Dolphin	*Delphinus delphis*	20	32.66117	-117.67633
2/15/2011 10:06:59	Risso's Dolphin	*Grampus griseus*	6	32.63033	-117.80867
2/15/2011 10:48:19	Risso's Dolphin	*Grampus griseus*	100	32.65333	-117.91817
2/15/2011 11:22:29	Risso's Dolphin	*Grampus griseus*	25	32.81517	-117.50433
2/15/2011 11:27:29	Common Dolphin sp.	undifferentiated *Delphinus*	80	32.83867	-117.33967
2/15/2011 11:28:09	Common Dolphin sp.	undifferentiated *Delphinus*	60	32.83983	-117.3175
2/15/2011 13:19:23	Bottlenose Dolphin	*Tursiops truncatus*	65	32.86183	-117.27117
2/15/2011 13:21:53	Common Dolphin sp.	undifferentiated *Delphinus*	50	32.90333	-117.34317
2/15/2011 13:24:03	Short-Beaked Common Dolphin	*Delphinus delphis*	500	32.92433	-117.4015
2/15/2011 13:41:03	Gray Whale	*Eschrichtius robustus*	1	32.85633	-117.76817
2/15/2011 14:00:43	Fin Whale	*Balaenoptera physalus*	1	32.83433	-118.22417
2/15/2011 14:06:53	Risso's Dolphin	*Grampus griseus*	8	32.912	-118.14183
2/15/2011 14:07:33	Unidentified Baleen Whale	undifferentiated *Balaenoptera*	1	32.92533	-118.14317

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
FEBRUARY SURVEY: 14-19 FEBRUARY 2011 (continued)					
2/15/2011 14:32:53	Fin Whale	*Balaenoptera physalus*	2	32.935	-118.03517
2/15/2011 14:59:33	Common Dolphin sp.	undifferentiated *Delphinus*	1000	33.069	-117.452
2/15/2011 15:00:03	Short-Beaked Common Dolphin	*Delphinus delphis*	500	33.07217	-117.435
2/15/2011 15:07:43	Gray Whale	*Eschrichtius robustus*	1	33.04417	-117.431
2/15/2011 15:18:53	Short-Beaked Common Dolphin	*Delphinus delphis*	900	33.16483	-117.54033
2/15/2011 15:34:23	Long-beaked Common Dolphin	*Delphinus capensis*	22	33.12733	-117.90383
2/15/2011 15:59:13	Unidentified Dolphin	unidentified Delphinidae	6	33.2705	-117.67333
2/15/2011 16:01:53	Common Dolphin sp.	undifferentiated *Delphinus*	1000	33.29333	-117.58683
2/15/2011 16:09:33	Common Dolphin sp.	undifferentiated *Delphinus*	700	33.1235	-117.441
2/15/2011 16:18:13	Unidentified Dolphin	unidentified Delphinidae	25	32.89983	-117.3155
2/15/2011 16:18:53	Unidentified Dolphin	unidentified Delphinidae	900	32.88383	-117.30217
2/17/2011 8:55:54	Bottlenose Dolphin	*Tursiops truncatus*	16	32.85967	-117.26283
2/17/2011 8:56:14	Gray Whale	*Eschrichtius robustus*	1	32.865	-117.27517
2/17/2011 8:56:44	Common Dolphin sp.	undifferentiated *Delphinus*	100	32.873	-117.294
2/17/2011 9:00:04	Unidentified Dolphin	unidentified Delphinidae	8	32.91567	-117.4245
2/17/2011 9:06:24	Fin Whale	*Balaenoptera physalus*	1	32.97817	-117.68117
2/17/2011 9:17:44	Unidentified Dolphin	unidentified Delphinidae	50	33.057	-118.13033
2/17/2011 9:22:24	Risso's Dolphin	*Grampus griseus*	19	33.08817	-118.31067
2/17/2011 9:23:24	Risso's Dolphin	*Grampus griseus*	3	33.09583	-118.3485
2/17/2011 9:37:04	Dall's Porpoise	*Phocoenoides dalli*	5	33.17067	-118.85483
2/17/2011 9:52:44	Long-Beaked Common Dolphin	*Delphinus capensis*	700	33.03267	-119.11117
2/17/2011 9:52:54	California Sea Lion	*Zalophus californianus*	1	33.03	-119.11617
2/17/2011 10:27:54	Short-Beaked Common Dolphin	*Delphinus delphis*	10	33.078	-118.894
2/17/2011 10:33:34	Short-Beaked Common Dolphin	*Delphinus delphis*	10	33.10933	-118.8385
2/17/2011 10:41:04	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.1265	-118.69483
2/17/2011 10:52:44	Unidentified Dolphin	unidentified Delphinidae	2	33.014	-118.4295
2/17/2011 11:27:14	California Sea Lion	*Zalophus californianus*	1	32.87383	-117.34517
2/17/2011 13:49:19	Common Dolphin sp.	undifferentiated *Delphinus*	25	32.86233	-117.26

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
FEBRUARY SURVEY: 14-19 FEBRUARY 2011 (continued)					
2/17/2011 13:49:39	Common Dolphin sp.	undifferentiated *Delphinus*	125	32.868	-117.27017
2/17/2011 13:52:29	California Sea Lion	*Zalophus californianus*	1	32.913	-117.35383
2/17/2011 13:54:29	California Sea Lion	*Zalophus californianus*	1	32.96317	-117.38633
2/17/2011 13:54:49	California Sea Lion	*Zalophus californianus*	1	32.97317	-117.38783
2/17/2011 13:56:49	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.03183	-117.39633
2/17/2011 13:56:59	California Sea Lion	*Zalophus californianus*	1	33.03683	-117.39733
2/17/2011 13:57:09	California Sea Lion	*Zalophus californianus*	1	33.04167	-117.39833
2/17/2011 14:01:39	California Sea Lion	*Zalophus californianus*	1	33.15817	-117.47267
2/17/2011 14:04:59	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.2345	-117.54483
2/17/2011 14:05:59	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.25567	-117.56817
2/17/2011 14:07:09	Common Dolphin sp.	undifferentiated *Delphinus*	300	33.279	-117.59733
2/17/2011 14:13:39	California Sea Lion	*Zalophus californianus*	1	33.36567	-117.77067
2/17/2011 14:14:49	Short-Beaked Common Dolphin	*Delphinus delphis*	1800	33.35867	-117.81017
2/17/2011 14:22:59	Minke Whale	*Balaenoptera acutorostrata*	1	33.34767	-117.90217
2/17/2011 14:35:09	Bottlenose Dolphin	*Tursiops truncatus*	2	33.301	-118.1165
2/17/2011 14:45:19	California Sea Lion	*Zalophus californianus*	2	33.2775	-118.24483
2/17/2011 14:46:09	California Sea Lion	*Zalophus californianus*	15	33.26983	-118.23267
2/17/2011 14:49:19	Unidentified Dolphin	unidentified Delphinidae	50	33.25983	-118.32533
2/17/2011 14:53:09	Gray Whale	*Eschrichtius robustus*	1	33.1855	-118.3915
2/17/2011 15:16:29	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.176	-118.3775
2/17/2011 15:37:09	Unidentified Dolphin	unidentified Delphinidae	100	33.06133	-118.10583
2/17/2011 15:42:19	Unidentified Dolphin	unidentified Delphinidae	250	33.01917	-118.056
2/17/2011 15:46:09	Common Dolphin sp.	undifferentiated *Delphinus*	75	32.987	-117.933
2/17/2011 15:46:39	Common Dolphin sp.	undifferentiated *Delphinus*	220	32.9825	-117.91683
2/17/2011 16:04:59	California Sea Lion	*Zalophus californianus*	4	32.85017	-117.2965
2/17/2011 16:05:19	California Sea Lion	*Zalophus californianus*	3	32.85	-117.285
2/18/2011 9:59:05	Bottlenose Dolphin	*Tursiops truncatus*	2	32.86083	-117.26433
2/18/2011 11:04:15	Risso's Dolphin	*Grampus griseus*	5	32.70467	-117.90983

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
FEBRUARY SURVEY: 14-19 FEBRUARY 2011 (continued)					
2/18/2011 11:14:04	Risso's Dolphin	*Grampus griseus*	12	32.73217	-117.82483
2/18/2011 12:28:45	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.68533	-117.29483
MARCH SURVEY: 30 MARCH - 01 APRIL 2011					
3/30/2011 17:40:51	Bottlenose Dolphin	*Tursiops truncatus*	5	32.88317	-117.26817
3/30/2011 17:41:21	Unidentified Dolphin	unidentified Delphinidae	25	32.89517	-117.27817
3/30/2011 17:45:37	Unidentified Dolphin	unidentified Delphinidae	300	32.9305	-117.39367
3/30/2011 18:07:18	Short-Beaked Common Dolphin	*Delphinus delphis*	40	33.056	-117.45817
3/30/2011 18:24:08	Common Dolphin sp.	undifferentiated *Delphinus*	18	33.12467	-117.626
3/30/2011 18:53:18	Bottlenose Dolphin	*Tursiops truncatus*	13	32.94633	-117.38633
3/30/2011 18:54:38	Common Dolphin sp.	undifferentiated *Delphinus*	50	32.91767	-117.3485
3/31/2011 8:54:44	Bottlenose Dolphin	*Tursiops truncatus*	3	32.85533	-117.297
3/31/2011 8:54:44	Bottlenose Dolphin	*Tursiops truncatus*	5	32.85533	-117.297
3/31/2011 9:02:14	California Sea Lion	*Zalophus californianus*	1	32.67767	-117.475
3/31/2011 9:36:04	Risso's Dolphin	*Grampus griseus*	18	32.775	-117.57733
3/31/2011 9:39:54	Minke Whale	*Balaenoptera acutorostrata*	1	32.7795	-117.5705
3/31/2011 9:44:54	Common Dolphin sp.	undifferentiated *Delphinus*	15	32.77067	-117.58067
3/31/2011 10:40:24	Minke Whale	*Balaenoptera acutorostrata*	2	32.79067	-117.47683
3/31/2011 11:02:34	Bottlenose Dolphin	*Tursiops truncatus*	12	32.8755	-117.39767
3/31/2011 11:11:54	Long-beaked Common Dolphin	*Delphinus capensis*	35	32.95567	-117.324
3/31/2011 15:06:45	Long-beaked Common Dolphin	*Delphinus capensis*	300	32.908	-117.484
3/31/2011 15:20:15	Common Dolphin sp.	undifferentiated *Delphinus*	225	32.84883	-117.76
3/31/2011 15:24:15	Gray Whale	*Eschrichtius robustus*	5	32.86083	-117.73583
3/31/2011 15:34:15	Common Dolphin sp.	undifferentiated *Delphinus*	25	32.83283	-117.87783
3/31/2011 15:36:45	Risso's Dolphin	*Grampus griseus*	35	32.82217	-117.96333
3/31/2011 15:38:35	Common Dolphin sp.	undifferentiated *Delphinus*	30	32.80317	-118.02317
3/31/2011 15:42:35	Risso's Dolphin	*Grampus griseus*	12	32.76667	-118.155
3/31/2011 16:10:45	Risso's Dolphin	*Grampus griseus*	20	32.8145	-118.24133
3/31/2011 16:38:05	Risso's Dolphin	*Grampus griseus*	22	32.90233	-118.18667

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
MARCH SURVEY: 30 MARCH - 01 APRIL 2011 (continued)					
3/31/2011 17:06:35	Unidentified Medium Whale	unidentified medium whale	1	32.95417	-117.89883
3/31/2011 17:10:55	Unidentified Small Marine Mammal	unidentified small marine mammal	1	32.98617	-117.73767
3/31/2011 17:13:15	Gray Whale	*Eschrichtius robustus*	2	33.00533	-117.65433
3/31/2011 17:21:25	Long-beaked Common Dolphin	*Delphinus capensis*	245	33.0405	-117.35767
3/31/2011 17:31:25	Common Dolphin sp.	undifferentiated *Delphinus*	11	32.89883	-117.2875
4/1/2011 8:39:48	Common Dolphin sp.	undifferentiated *Delphinus*	10	32.84783	-117.33833
4/1/2011 8:42:48	Common Dolphin sp.	undifferentiated *Delphinus*	20	32.8385	-117.4535
4/1/2011 8:44:38	Common Dolphin sp.	undifferentiated *Delphinus*	20	32.83117	-117.5225
4/1/2011 8:44:58	Common Dolphin sp.	undifferentiated *Delphinus*	250	32.82933	-117.5355
4/1/2011 8:53:28	Common Dolphin sp.	undifferentiated *Delphinus*	15	32.79533	-117.87267
4/1/2011 8:56:08	Unidentified Small Dolphin	unidentified small dolphin	20	32.7845	-117.97767
4/1/2011 8:56:38	Risso's Dolphin	*Grampus griseus*	12	32.78183	-117.99717
4/1/2011 8:57:18	Risso's Dolphin	*Grampus griseus*	8	32.77867	-118.02317
4/1/2011 8:58:48	Common Dolphin sp.	undifferentiated *Delphinus*	6	32.772	-118.08267
4/1/2011 9:03:58	Gray Whale	*Eschrichtius robustus*	2	32.768	-118.28867
4/1/2011 9:04:58	Unidentified Dolphin	unidentified Delphinidae	22	32.77233	-118.32867
4/1/2011 9:05:28	Common Dolphin sp.	undifferentiated *Delphinus*	3	32.77333	-118.34883
4/1/2011 9:06:38	Unidentified Dolphin	unidentified Delphinidae	100	32.77633	-118.39533
4/1/2011 9:06:58	California Sea Lion	*Zalophus californianus*	2	32.77667	-118.40867
4/1/2011 9:07:08	California Sea Lion	*Zalophus californianus*	2	32.7765	-118.41517
4/1/2011 9:08:08	California Sea Lion	*Zalophus californianus*	1	32.782	-118.45217
4/1/2011 9:08:28	California Sea Lion	*Zalophus californianus*	1	32.78483	-118.464
4/1/2011 9:09:28	California Sea Lion	*Zalophus californianus*	2	32.79283	-118.49933
4/1/2011 9:09:58	California Sea Lion	*Zalophus californianus*	1	32.79683	-118.51683
4/1/2011 9:10:08	California Sea Lion	*Zalophus californianus*	1	32.798	-118.52267
4/1/2011 9:10:48	Unidentified Dolphin	unidentified Delphinidae	2	32.803	-118.54617
4/1/2011 9:10:48	California Sea Lion	*Zalophus californianus*	1	32.803	-118.54617
4/1/2011 9:12:18	California Sea Lion	*Zalophus californianus*	1	32.8345	-118.58333

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
MARCH SURVEY: 30 MARCH - 01 APRIL 2011 (continued)					
4/1/2011 9:17:28	Risso's Dolphin	*Grampus griseus*	20	32.95567	-118.69717
4/1/2011 9:28:28	Northern Right Whale Dolphin	*Lissodelphis borealis*	8	32.9515	-118.67733
4/1/2011 9:52:38	Risso's Dolphin	*Grampus griseus*	18	32.91667	-118.6955
4/1/2011 9:56:28	Risso's Dolphin	*Grampus griseus*	2	32.94283	-118.68383
4/1/2011 9:58:38	Risso's Dolphin	*Grampus griseus*	11	33.0015	-118.70867
4/1/2011 10:00:38	Northern Right Whale Dolphin	*Lissodelphis borealis*	2	33.013	-118.70783
4/1/2011 10:02:48	Gray Whale	*Eschrichtius robustus*	3	33.031	-118.71667
4/1/2011 10:10:18	Northern Right Whale Dolphin	*Lissodelphis borealis*	25	32.9965	-118.728
4/1/2011 10:18:08	Northern Right Whale Dolphin	*Lissodelphis borealis*	20	33.0075	-118.69933
4/1/2011 10:28:08	Gray Whale	*Eschrichtius robustus*	2	33.037	-118.686
4/1/2011 10:28:08	Risso's Dolphin	*Grampus griseus*	11	33.037	-118.686
4/1/2011 10:30:18	Risso's Dolphin	*Grampus griseus*	12	33.09867	-118.63117
4/1/2011 10:30:58	Risso's Dolphin	*Grampus griseus*	20	33.10517	-118.6055
4/1/2011 10:34:28	Fin/Sei/Bryde's Whale	*Balaenoptera physalus/borealis/edeni*	1	33.07067	-118.467
4/1/2011 10:40:38	Risso's Dolphin	*Grampus griseus*	11	33.02083	-118.21433
4/1/2011 10:44:48	Humpback Whale	*Megaptera novaeangliae*	2	32.99017	-118.04617
4/1/2011 10:55:58	Unidentified Whale	unidentified whale	3	32.9065	-117.614
4/1/2011 11:04:08	Common Dolphin sp.	undifferentiated *Delphinus*	15	32.853	-117.29633
APRIL SURVEY: 12-19 APRIL 2011					
4/12/2011 11:46:19	Common Dolphin sp.	undifferentiated *Delphinus*	440	32.69917	-117.4735
4/12/2011 12:20:36	Common Dolphin sp.	undifferentiated *Delphinus*	85	32.646	-117.69
4/12/2011 12:23:46	Risso's Dolphin	*Grampus griseus*	3	32.654	-117.69317
4/12/2011 12:32:35	Risso's Dolphin	*Grampus griseus*	25	32.61783	-117.805
4/12/2011 13:12:02	Risso's Dolphin	*Grampus griseus*	40	32.74667	-117.65367
4/12/2011 13:20:32	Risso's Dolphin	*Grampus griseus*	25	32.76917	-117.553
4/12/2011 13:40:02	Common Dolphin sp.	undifferentiated *Delphinus*	30	32.84033	-117.80183
4/12/2011 14:08:51	Risso's Dolphin	*Grampus griseus*	20	32.91267	-117.96617
4/12/2011 14:19:41	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.97717	-117.772

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
APRIL SURVEY: 12-19 APRIL 2011 (continued)					
4/12/2011 14:45:21	Common Dolphin sp.	undifferentiated *Delphinus*	15	33.0385	-117.972
4/12/2011 15:45:41	Fin Whale	*Balaenoptera physalus*	2	33.24417	-118.45333
4/12/2011 16:42:20	Common Dolphin sp.	undifferentiated *Delphinus*	855	33.277	-118.352
4/12/2011 16:59:50	Unidentified Dolphin	unidentified Delphinidae	4	33.424	-118.11283
4/12/2011 17:00:20	Unidentified Dolphin	unidentified Delphinidae	18	33.41433	-118.09233
4/13/2011 10:51:24	Common Dolphin sp.	undifferentiated *Delphinus*	80	32.611	-117.189
4/13/2011 10:55:14	Unidentified Dolphin	unidentified Delphinidae	30	32.66083	-117.36517
4/13/2011 10:58:14	Gray Whale	*Eschrichtius robustus*	3	32.69133	-117.4725
4/13/2011 11:34:55	Risso's Dolphin	*Grampus griseus*	24	32.72967	-117.53683
4/13/2011 11:47:35	Risso's Dolphin	*Grampus griseus*	8	32.74733	-117.53133
4/13/2011 12:19:55	Bottlenose Dolphin	*Tursiops truncatus*	55	32.8305	-117.42483
4/13/2011 12:33:41	Common Dolphin sp.	undifferentiated *Delphinus*	80	32.968	-117.37633
4/13/2011 12:34:21	Common Dolphin sp.	undifferentiated *Delphinus*	125	32.973	-117.40033
4/13/2011 13:04:40	Common Dolphin sp.	undifferentiated *Delphinus*	10	32.937	-117.73367
4/13/2011 13:13:20	Common Dolphin sp.	undifferentiated *Delphinus*	35	33.05933	-117.39383
4/13/2011 13:45:00	Unidentified Dolphin	unidentified Delphinidae	2	33.1845	-117.92867
4/13/2011 13:52:20	Common Dolphin sp.	undifferentiated *Delphinus*	90	33.26283	-117.63583
4/13/2011 13:59:09	Unidentified Dolphin	unidentified Delphinidae	5	33.30717	-117.60583
4/13/2011 14:12:39	Unidentified Dolphin	unidentified Delphinidae	75	33.2985	-118.11783
4/13/2011 14:39:36	Unidentified Dolphin	unidentified Delphinidae	40	33.44817	-117.9375
4/13/2011 14:57:26	Common Dolphin sp.	undifferentiated *Delphinus*	45	33.2685	-117.63133
4/13/2011 14:57:56	Common Dolphin sp.	undifferentiated *Delphinus*	450	33.255	-117.61933
4/13/2011 15:17:36	Common Dolphin sp.	undifferentiated *Delphinus*	23	33.14167	-117.48233
4/13/2011 15:18:56	Common Dolphin sp.	undifferentiated *Delphinus*	24	33.0975	-117.46433
4/13/2011 15:23:06	Dall's Porpoise	*Phocoenoides dalli*	3	32.964	-117.47483
4/14/2011 9:14:26	Unidentified Dolphin	unidentified Delphinidae	4	32.605	-117.17383
4/14/2011 9:14:56	Common Dolphin sp.	undifferentiated *Delphinus*	75	32.6125	-117.19633
4/14/2011 9:20:56	Unidentified Baleen Whale	undifferentiated *Balaenoptera*	1	32.70183	-117.4725

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
APRIL SURVEY: 12-19 APRIL 2011 (continued)					
4/14/2011 9:21:36	Unidentified Dolphin	unidentified Delphinidae	40	32.7115	-117.50183
4/14/2011 9:27:56	Risso's Dolphin	*Grampus griseus*	20	32.806	-117.77467
4/14/2011 9:44:06	Common Dolphin sp.	undifferentiated *Delphinus*	18	33.031	-118.48533
4/14/2011 10:17:46	Fin Whale	*Balaenoptera physalus*	1	33.10117	-118.86283
4/14/2011 11:02:56	Fin Whale	*Balaenoptera physalus*	2	33.09417	-118.85133
4/14/2011 11:08:46	Fin Whale	*Balaenoptera physalus*	1	33.10133	-118.86183
4/14/2011 11:41:48	Risso's Dolphin	*Grampus griseus*	60	33.08317	-118.76567
4/14/2011 12:06:49	Unidentified Whale	unidentified whale	1	33.00683	-118.87433
4/14/2011 12:45:25	Common Dolphin sp.	undifferentiated *Delphinus*	55	32.8845	-118.90883
4/14/2011 13:27:25	Common Dolphin sp.	undifferentiated *Delphinus*	700	32.8455	-118.6055
4/14/2011 14:02:55	Risso's Dolphin	*Grampus griseus*	556	32.59167	-117.794
4/15/2011 8:38:14	Bottlenose Dolphin	*Tursiops truncatus*	15	32.60133	-117.2685
4/15/2011 8:42:54	Bottlenose Dolphin	*Tursiops truncatus*	25	32.676	-117.46067
4/15/2011 9:16:24	Fin Whale	*Balaenoptera physalus*	4	32.77317	-117.5895
4/15/2011 9:53:04	Minke Whale	*Balaenoptera acutorostrata*	2	32.7745	-117.5975
4/15/2011 10:33:13	Common Dolphin sp.	undifferentiated *Delphinus*	250	32.78633	-117.511
4/15/2011 10:59:53	Humpback Whale	*Megaptera novaeangliae*	1	32.83867	-117.85283
4/15/2011 11:20:33	Risso's Dolphin	*Grampus griseus*	19	32.781	-118.07567
4/15/2011 11:44:53	Risso's Dolphin	*Grampus griseus*	8	32.77417	-118.19767
4/15/2011 12:10:43	Risso's Dolphin	*Grampus griseus*	10	32.937	-117.96267
4/15/2011 12:12:53	Fin Whale	*Balaenoptera physalus*	2	32.95933	-117.88417
4/15/2011 12:19:13	Unidentified Whale	unidentified whale	2	32.9315	-117.8635
4/15/2011 12:37:03	Short-Beaked Common Dolphin	*Delphinus delphis*	1200	33.06033	-117.43433
4/15/2011 12:51:53	California Sea Lion	*Zalophus californianus*	1	32.83583	-117.31567
4/15/2011 12:54:53	California Sea Lion	*Zalophus californianus*	2	32.73567	-117.27867
4/15/2011 14:49:13	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.771	-117.41067
4/15/2011 15:06:23	Risso's Dolphin	*Grampus griseus*	2	33.135	-117.642
4/15/2011 15:10:13	Unidentified Dolphin	unidentified Delphinidae	450	33.11817	-117.78417

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
APRIL SURVEY: 12-19 APRIL 2011 (continued)					
4/15/2011 15:28:53	Short-Beaked Common Dolphin	*Delphinus delphis*	1100	33.0165	-118.194
4/15/2011 15:45:13	Risso's Dolphin	*Grampus griseus*	24	33.08117	-118.41067
4/15/2011 16:04:03	Risso's Dolphin	*Grampus griseus*	23	33.09467	-118.34967
4/15/2011 16:24:03	Fin Whale	*Balaenoptera physalus*	1	33.20933	-117.85733
4/16/2011 13:04:50	Bottlenose Dolphin	*Tursiops truncatus*	10	32.6025	-117.25967
4/16/2011 13:20:30	Common Dolphin sp.	undifferentiated *Delphinus*	250	32.8985	-117.89717
4/16/2011 13:27:10	Minke Whale	*Balaenoptera acutorostrata*	1	33.001	-118.19467
4/16/2011 13:30:40	Risso's Dolphin	*Grampus griseus*	9	33.051	-118.355
4/16/2011 13:39:50	Risso's Dolphin	*Grampus griseus*	1	33.166	-118.763
4/16/2011 13:46:20	Risso's Dolphin	*Grampus griseus*	1	33.15883	-118.7295
4/16/2011 13:52:10	Unidentified Large Whale	unidentified large whale	1	33.05583	-118.94467
4/16/2011 14:21:48	Northern Right Whale Dolphin	*Lissodelphis borealis*	6	33.014	-118.86233
4/16/2011 14:29:36	Gray Whale	*Eschrichtius robustus*	1	33.09317	-118.66967
4/16/2011 14:36:59	Northern Right Whale Dolphin	*Lissodelphis borealis*	4	32.9605	-118.83533
4/16/2011 14:46:19	Common Dolphin sp.	undifferentiated *Delphinus*	200	32.90267	-118.82267
4/16/2011 15:00:51	Unidentified Small Marine Mammal	unidentified small marine mammal	1	32.85833	-118.76033
4/16/2011 15:10:41	Fin Whale	*Balaenoptera physalus*	1	32.83883	-118.69867
4/16/2011 16:09:31	Long-Beaked Common Dolphin	*Delphinus capensis*	300	32.64967	-117.98067
4/16/2011 16:29:31	Unidentified Dolphin	unidentified Delphinidae	3	32.57383	-117.4905
4/16/2011 16:31:41	Humpback Whale	*Megaptera novaeangliae*	1	32.56317	-117.4025
4/17/2011 14:30:43	Unidentified Dolphin	unidentified Delphinidae	5	32.61583	-117.285
4/18/2011 12:51:50	Risso's Dolphin	*Grampus griseus*	18	32.702	-117.5
4/18/2011 12:52:30	Risso's Dolphin	*Grampus griseus*	35	32.726	-117.48933
4/18/2011 13:15:09	Risso's Dolphin	*Grampus griseus*	7	33.076	-117.67783
4/18/2011 13:19:59	Bottlenose Dolphin	*Tursiops truncatus*	5	33.08017	-117.66633
4/18/2011 14:07:23	Risso's Dolphin	*Grampus griseus*	12	33.11117	-117.95583
4/18/2011 14:09:23	Unidentified Small Whale	unidentified small whale	1	33.09667	-117.99083
4/18/2011 15:13:19	Bottlense Dolphin	Tursiops truncatus	4	33.18167	-118.00317

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
APRIL SURVEY: 12-19 APRIL 2011 (continued)					
4/18/2011 15:13:29	Risso's Dolphin	*Grampus griseus*	40	33.1795	-118.01067
4/18/2011 15:44:48	Unidentified Dolphin	unidentified Delphinidae	22	33.31267	-117.5725
4/18/2011 15:46:08	California Sea Lion	*Zalophus californianus*	2	33.34283	-117.628
4/18/2011 15:46:48	Unidentified Dolphin	unidentified Delphinidae	3	33.3595	-117.65317
4/18/2011 16:14:38	Unidentified Dolphin	unidentified Delphinidae	2	33.36117	-117.78133
4/18/2011 16:17:58	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.35083	-117.66267
4/18/2011 16:25:48	Common Dolphin sp.	undifferentiated *Delphinus*	145	33.2455	-117.68017
4/18/2011 16:55:37	Bottlenose Dolphin	*Tursiops truncatus*	32	33.14117	-117.57317
4/18/2011 17:18:46	Long-Beaked Common Dolphin	*Delphinus capensis*	175	33.0475	-117.4015
4/18/2011 17:26:36	Common Dolphin sp.	undifferentiated *Delphinus*	70	33.0315	-117.53433
4/18/2011 17:40:16	Unidentified Dolphin	unidentified Delphinidae	10	32.91667	-117.45983
4/18/2011 17:43:26	Common Dolphin sp.	undifferentiated *Delphinus*	105	32.92383	-117.34
4/19/2011 10:30:13	Common Dolphin sp.	undifferentiated *Delphinus*	25	32.78467	-117.41217
4/19/2011 10:35:32	Fin Whale	*Balaenoptera physalus*	3	32.82383	-117.4235
4/19/2011 11:25:42	Common Dolphin sp.	undifferentiated *Delphinus*	120	33.39767	-117.76433
4/19/2011 11:34:11	Unidentified Dolphin	unidentified Delphinidae	10	33.45267	-117.95033
4/19/2011 11:41:51	Long-Beaked Common Dolphin	*Delphinus capensis*	350	33.3935	-118.2365
4/19/2011 12:00:59	Common Dolphin sp.	undifferentiated *Delphinus*	150	33.31617	-118.19233
4/19/2011 12:04:09	Risso's Dolphin	*Grampus griseus*	25	33.31783	-118.21
4/19/2011 12:31:58	Common Dolphin sp.	undifferentiated *Delphinus*	225	33.33667	-117.9435
4/19/2011 12:55:38	Gray Whale	*Eschrichtius robustus*	2	33.07183	-117.47533
4/19/2011 13:14:27	Gray Whale	*Eschrichtius robustus*	1	33.08017	-117.55933
4/19/2011 13:27:57	Unidentified Medium Cetacean	unidentified medium cetacean	1	32.67133	-117.37483
4/19/2011 15:53:34	Fin Whale	*Balaenoptera physalus*	1	32.73133	-117.45883
4/19/2011 16:06:34	Unidentified Whale	unidentified whale	1	32.69883	-117.43517
4/19/2011 16:11:44	Fin Whale	*Balaenoptera physalus*	1	32.75483	-117.47983
4/19/2011 16:42:13	Common Dolphin sp.	undifferentiated *Delphinus*	100	33.1245	-117.64167
4/19/2011 17:09:42	Short-Beaked Common Dolphin	*Delphinus delphis*	1750	32.87483	-117.40033

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
APRIL SURVEY: 12-19 APRIL 2011 (continued)					
4/19/2011 17:38:31	California Sea Lion	*Zalophus californianus*	1	32.6775	-117.211
4/19/2011 17:49:31	Risso's Dolphin	*Grampus griseus*	24	32.64517	-117.45417
4/19/2011 18:08:34	Risso's Dolphin	*Grampus griseus*	8	32.60083	-117.56083
4/20/2011 10:10:31	Short-Beaked Common Dolphin	*Delphinus delphis*	45	32.5505	-117.28417
4/20/2011 10:27:44	Fin Whale	*Balaenoptera physalus*	1	32.53817	-117.39217
4/20/2011 10:30:53	Common Dolphin sp.	undifferentiated *Delphinus*	350	32.5295	-117.37617
4/20/2011 10:33:03	Blue Whale	*Balaenoptera musculus*	2	32.52133	-117.34683
4/20/2011 11:21:08	Unidentified Small Marine Mammal	unidentified small marine mammal	1	32.56583	-117.3465
4/20/2011 11:28:58	Common Dolphin sp.	undifferentiated *Delphinus*	35	32.53517	-117.4155
4/20/2011 12:42:47	Blue Whale	*Balaenoptera musculus*	1	32.6075	-117.36217
4/20/2011 13:23:34	Blue Whale	*Balaenoptera musculus*	1	32.60383	-117.3565
4/20/2011 13:45:49	Risso's Dolphin	*Grampus griseus*	22	32.5835	-117.89383
4/20/2011 14:19:29	Common Dolphin sp.	undifferentiated *Delphinus*	22	32.624	-117.4545
4/20/2011 14:22:18	Long-Beaked Common Dolphin	*Delphinus capensis*	800	32.632	-117.43667
4/20/2011 15:27:16	Long-Beaked Common Dolphin	*Delphinus capensis*	275	32.54017	-117.329
MAY SURVEY: 09-14 MAY 2011					
5/9/2011 15:37:55	Common Dolphin sp.	undifferentiated *Delphinus*	50	33.37983	-117.688
5/9/2011 15:44:15	California Sea Lion	*Zalophus californianus*	1	33.28617	-117.58433
5/9/2011 15:46:35	Blue Whale	*Balaenoptera musculus*	1	33.243	-117.53467
5/9/2011 15:47:55	Fin Whale	*Balaenoptera physalus*	2	33.2515	-117.54317
5/10/2011 9:35:30	Unidentified Dolphin	unidentified Delphinidae	40	32.8635	-117.28067
5/10/2011 9:42:01	Blue Whale	*Balaenoptera musculus*	2	32.791	-117.38567
5/10/2011 9:44:26	Bottlenose Dolphin	*Tursiops truncatus*	10	32.79	-117.3975
5/10/2011 9:55:59	Fin Whale	*Balaenoptera physalus*	1	32.77867	-117.4005
5/10/2011 10:33:16	California Sea Lion	*Zalophus californianus*	1	32.8015	-117.38367
5/10/2011 10:40:29	Harbor Seal	*Phoca vitulina*	3	32.79983	-117.37333
5/10/2011 10:40:29	California Sea Lion	*Zalophus californianus*	2	32.79983	-117.37333
5/10/2011 10:59:11	Risso's Dolphin	*Grampus griseus*	16	32.81267	-117.35833

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
MAY SURVEY: 09-14 MAY 2011 (continued)					
5/10/2011 11:05:12	Bottlenose Dolphin	*Tursiops truncatus*	3	32.806	-117.36433
5/10/2011 11:19:36	Harbor Seal	*Phoca vitulina*	1	32.696	-117.432
5/10/2011 11:32:46	Short-Beaked Common Dolphin	*Delphinus delphis*	140	32.6065	-117.84783
5/10/2011 11:40:03	Short-Beaked Common Dolphin	*Delphinus delphis*	625	32.604	-117.8755
5/10/2011 12:06:23	Humpback Whale	*Megaptera novaeangliae*	1	32.76633	-117.60217
5/10/2011 12:19:16	Risso's Dolphin	*Grampus griseus*	9	32.78167	-117.5445
5/10/2011 12:41:21	Common Dolphin sp.	undifferentiated *Delphinus*	120	32.79783	-117.45167
5/10/2011 12:45:22	Blue Whale	*Balaenoptera musculus*	1	32.90217	-117.38017
5/10/2011 12:50:27	Unidentified Dolphin	unidentified Delphinidae	20	32.94383	-117.31917
5/10/2011 12:51:22	Unidentified Medium Whale	unidentified medium whale	4	32.92183	-117.29967
5/10/2011 15:32:57	Common Dolphin sp.	undifferentiated *Delphinus*	30	33.04683	-117.4315
5/10/2011 15:42:07	Unidentified Dolphin	unidentified Delphinidae	6	32.95817	-117.29167
5/10/2011 15:46:27	Fin Whale	*Balaenoptera physalus*	2	32.87783	-117.30467
5/10/2011 15:55:17	Blue Whale	*Balaenoptera musculus*	2	32.87733	-117.31383
5/10/2011 16:08:27	Blue Whale	*Balaenoptera musculus*	1	32.86767	-117.33017
5/10/2011 16:25:57	Blue Whale	*Balaenoptera musculus*	1	32.86433	-117.34617
5/10/2011 16:50:57	Blue Whale	*Balaenoptera musculus*	1	32.87583	-117.32933
5/11/2011 9:51:03	Blue Whale	*Balaenoptera musculus*	1	32.84283	-117.37417
5/11/2011 10:04:53	Blue Whale	*Balaenoptera musculus*	1	32.85933	-117.35467
5/11/2011 10:14:13	California Sea Lion	*Zalophus californianus*	1	32.85167	-117.35583
5/11/2011 10:58:42	Blue Whale	*Balaenoptera musculus*	1	32.877	-117.34083
5/11/2011 13:58:10	Common Dolphin sp.	undifferentiated *Delphinus*	40	32.6625	-117.58583
5/11/2011 13:58:10	Risso's Dolphin	*Grampus griseus*	32	32.6625	-117.58583
5/11/2011 13:59:30	Bottlenose Dolphin	*Tursiops truncatus*	8	32.673	-117.575
5/11/2011 14:41:19	California Sea Lion	*Zalophus californianus*	1	32.59217	-117.64117
5/11/2011 15:04:29	Risso's Dolphin	*Grampus griseus*	7	32.80117	-117.98383
5/11/2011 15:27:09	Risso's Dolphin	*Grampus griseus*	4	32.798	-118.01133
5/11/2011 15:59:49	Humpback Whale	*Megaptera novaeangliae*	1	32.81417	-117.35517

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
MAY SURVEY: 09-14 MAY 2011 (continued)					
5/12/2011 10:26:22	Bottlenose Dolphin	*Tursiops truncatus*	16	32.86567	-117.28467
5/12/2011 10:50:12	Bottlenose Dolphin	*Tursiops truncatus*	50	32.747	-118.22567
5/12/2011 10:57:02	Risso's Dolphin	*Grampus griseus*	6	32.7115	-118.4855
5/12/2011 10:57:12	Unidentified Baleen Whale	undifferentiated *Balaenoptera*	1	32.71033	-118.49167
5/12/2011 11:04:42	Unidentified Baleen Whale	undifferentiated *Balaenoptera*	1	32.66783	-118.75183
5/12/2011 11:13:52	Short-Beaked Common Dolphin	*Delphinus delphis*	350	32.80817	-118.54583
5/12/2011 12:46:22	Fin Whale	*Balaenoptera physalus*	1	32.7475	-118.65417
5/12/2011 13:29:12	Unidentified Dolphin	unidentified Delphinidae	250	32.84283	-118.554
5/12/2011 13:29:22	Unidentified Dolphin	unidentified Delphinidae	150	32.8465	-118.54867
5/12/2011 13:50:22	Common Dolphin sp.	undifferentiated *Delphinus*	125	32.994	-118.1055
5/12/2011 13:56:22	Unidentified Baleen Whale	undifferentiated *Balaenoptera*	1	32.954	-117.87733
5/12/2011 16:03:05	Fin Whale	*Balaenoptera physalus*	1	32.60067	-117.565
5/12/2011 16:44:05	Fin Whale	*Balaenoptera physalus*	1	32.60417	-117.56667
5/12/2011 16:54:55	Risso's Dolphin	*Grampus griseus*	14	32.51917	-117.5915
5/12/2011 17:36:55	Common Dolphin sp.	undifferentiated *Delphinus*	30	32.8035	-117.34117
5/13/2011 13:28:42	Common Dolphin sp.	undifferentiated *Delphinus*	25	32.85883	-117.28933
5/13/2011 13:36:02	Common Dolphin sp.	undifferentiated *Delphinus*	175	32.935	-117.2945
5/13/2011 13:42:02	Common Dolphin sp.	undifferentiated *Delphinus*	400	32.87517	-117.29217
5/13/2011 13:49:22	Common Dolphin sp.	undifferentiated *Delphinus*	300	32.78717	-117.3635
5/13/2011 13:57:22	Fin Whale	*Balaenoptera physalus*	2	32.6235	-117.52467
5/13/2011 14:20:32	Minke Whale	*Balaenoptera acutorostrata*	1	32.62283	-117.49333
5/13/2011 14:40:52	Fin Whale	*Balaenoptera physalus*	1	32.70267	-117.61617
5/13/2011 15:05:56	Unidentified Dolphin	unidentified Delphinidae	5	32.5855	-117.64217
5/13/2011 15:19:56	Unidentified Baleen Whale	undifferentiated *Balaenoptera*	2	32.56967	-117.67883
5/13/2011 16:40:57	Fin Whale	*Balaenoptera physalus*	1	32.99517	-117.583
5/14/2011 9:43:54	California Sea Lion	*Zalophus californianus*	1	32.72483	-117.685
5/14/2011 10:00:54	California Sea Lion	*Zalophus californianus*	3	32.67567	-117.21883
5/14/2011 10:01:44	California Sea Lion	*Zalophus californianus*	1	32.67717	-117.18983

Date & Time	Species Common Name	Species Scientific Name	Group Size	Latitude	Longitude
MAY SURVEY: 09-14 MAY 2011 (continued)					
5/14/2011 10:09:24	California Sea Lion	*Zalophus californianus*	25	32.65067	-117.31
5/14/2011 10:21:54	Bottlenose Dolphin	*Tursiops truncatus*	40	32.65517	-117.4315
5/14/2011 10:36:14	Sperm Whale	*Physeter macrocephalus*	20	32.617	-117.72617
5/14/2011 10:41:24	Risso's Dolphin	*Grampus griseus*	11	32.62283	-117.72467
5/14/2011 10:41:24	Northern Right Whale Dolphin	*Lissodelphis borealis*	50	32.62283	-117.72467
5/14/2011 11:51:04	California Sea Lion	*Zalophus californianus*	1	32.61567	-117.4085
5/14/2011 11:56:04	California Sea Lion	*Zalophus californianus*	1	32.619	-117.37917
5/14/2011 12:02:14	California Sea Lion	*Zalophus californianus*	1	32.6235	-117.1655
5/14/2011 12:02:44	California Sea Lion	*Zalophus californianus*	1	32.62517	-117.1475
5/14/2011 12:10:24	Risso's Dolphin	*Grampus griseus*	1	32.58467	-117.31433
5/14/2011 12:24:34	Blue Whale	*Balaenoptera musculus*	1	32.7695	-117.37717
5/14/2011 13:29:05	Unidentified Dolphin	unidentified Delphinidae	30	32.85667	-117.36817
5/14/2011 13:32:25	Blue Whale	*Balaenoptera musculus*	2	32.76567	-117.3895

Table 5. Summary of Flight Effort during SOCAL Marine Mammal Aerial Survey Monitoring 23–28 September 2010.

Date 2010	Platform	Location	Time Lift Off	Time Landed	Total Flight Time	Total Engine Time	Total "On Effort" Observ	MTE-assoc. MFAS?	Survey Notes
23-Sep	Partenavia OBS	n/a	14:10	14:12	0:02	n/a	n/a	n/a	Headed SW to NAOPA line; as soon as we took off had to land again pilot says nose of plane feels heavy so we redistributed weight in plane
23-Sep	Partenavia OBS	S NAOPA	14:20	17:33	3:13	3:38	3:06	Yes	Second take-off today; completed 4 southernmost NAOPA lines, relatively few sightings compared to previous surveys
24-Sep	Partenavia OBS	N SOAR	11:42	14:57	3:15	3:25	3:10	No	First survey flight flew straight to N SOAR did 4 N legs at SOAR then flew back; fog nearshore on way in morning, no observing until part-way through transit. Focal on blue whale and common dolphins.
24-Sep	Partenavia OBS	Coastal NAOPA	16:05	17:41	1:36	1:54	1:46	No	Second flight of day-we flew N about 10 nm from shore, hit Bf 5, then turned back and headed S about 5 nm offshore and went in to airport
25-Sep	Partenavia OBS	NE SOAR	10:19	13:37	3:18	3:28	3:13	No	Headed straight out to T2 in NE SOAR where BRS vessel was this morning; did not circle any groups on way out because needed to conserve fuel for coordination with BRS and SOAR survey
26-Sep	Partenavia OBS	N SOAR	10:35	14:18	3:43	3:50	3:36	No	Flew straight to N SOAR since BRS vessel restricted to N SOAR; we will call them on vhf 16 when we get near SOAR and see if they need us for anything. Otherwise we will survey N SOAR start an E end of Line 1 in northernmost SOAR. We are flying at 1000 ft altitude doing line transect surveys. Our tail number is zero two lima (02L). Focals on common dolphins.
26-Sep	Partenavia OBS	Coastal NAOPA	15:24	17:25	2:01	2:19	1:54	No	Second flight of day. Plan is to head N parallel shore by about 8 nm and look for feeding commons or Risso's or whales to do focal video behavioral sessions on.

Date 2010	Platform	Location	Time Lift Off	Time Landed	Total Flight Time	Total Engine Time	Total "On Effort" Observ	MTE-assoc. MFAS?	Survey Notes
27-Sep	Partenavia OBS	N SOAR	9:38	13:34	3:56	4:07	3:49	Yes	Flew straight over to N SOAR Line 1 flew this line E to W then talked to BRS R/V Sproul and they asked us to help them find whales just N of SOAR Range in NW corner and to relocate beaked whales so we flew there and flew improvised systematic lines 1 nm apart paralleling SOAR lines and 3 nm long, saw 3 minkes and Sproul had seen 2 minkes earlier this morning. Did focals on 2 groups of Risso's before and after seeing Sproul may have been same group. VERY HOT in plane today, 95 degrees. Focal on Risso's dolphins and minke whales.
27-Sep	Partenavia OBS	W NAOPA	14:37	16:32	1:55	1:59	1:48	Yes	Second flight of today. Headed W on NAOPA Line 4 to SCI and will then head N along underwater drop off where we often see deep-water species such as Pacific white-sided dolphins, Risso's, beaked, so we can let BRS know since they can't be on SOAR tomorrow. Focals on common dolphins.
28-Sep	Partenavia OBS	Coastal NAOPA	8:44	11:02	2:18	2:29	2:11	No	We did a short local behavior flight this morning and then attempted to assist BRS in Santa Catalina Basin but this region was not accessible to us per Navy communications. BRS has asked us to assist in locating animals since they will not be in SOAR and thus the hydrophone Moretti range to put them on animals. Focal on sei/Brydes whales lunge feeding.
28-Sep	Partenavia OBS	N NAOPA	11:55	15:14	3:19	3:25	3:12	No	Took off from Oxnard airport where we refueled and headed W to San Clemente Island. Focal on Risso's dolphins.
		Total Flight Time:			**28:51:00**	**30:37:00**	**27:27:00**		

Table 6. Summary of Flight Effort during SOCAL Marine Mammal Aerial Survey Monitoring 14–18 February 2011. Note: No survey occurred 16 and 19 February due to inclement weather.

Date	Flight of Day	Time Engines On	Time Engines Off	Total Engine Time	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Dist (km)	Total Flight Dist (nm)	Start Obs.	End Obs.	Total Obs. Time	Flight Area	General Weather	Comments
14 Feb	1	13:08	14:35	1:27	13:10	14:34	1:24	239	129	13:18	14:32	1:14	S of Point Loma near Mexican airspace in Silver Strand†	Bf 2-3	Coordinated with Scripps' RHIB to find unid. whale. Guided RHIB to bottlenose dolphins off Encinitas.
14 Feb	2	15:25	17:22	1:57	15:26	17:23	1:57	342	184	15:34	17:20	1:46	Near E end of Line 3 NAOPA - coordinated with Scripps RHIB to look for focals	Bf 2-3	Coordinated with Scripps' RHIB in attempt to find unid. whale.
15 Feb	1	8:29	11:36	3:07	8:31	11:37	3:06	513	277	8:40	11:34	2:54	S NAOPA	Clear skies Bf 1-2	Scripps' RHIB could not launch due to large swells.
15 Feb	2	13:09	16:25	3:16	13:11	16:26	3:15	561	303	13:16	16:25	3:09	Central NAOPA	Clear skies Bf 1-2	-
16 Feb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No flight	Thunderstorms and heavy clouds	Unable to fly due to weather
17 Feb	1	8:43	11:37	2:54	8:52	11:34	2:42	521	281	8:58	11:29	2:31	N SOAR	Clear skies Bf 2	SOAR open only in morning
17 Feb	2	13:36	16:13	2:37	13:42	16:10	2:28	439	237	13:48	16:07	2:19	N NAOPA	Clear skies Bf 2	-
18 Feb	1	9:43	13:01	3:18	9:48	12:59	3:11	598	323	9:54	12:44	2:50	SW & W NAOPA; Carlsbad to Mt. Soledad; S of Pt Loma toward Silver Strand ‡	Partly cloudy, Bf 3-5, thunderstorms started in afternoon	SOAR open in morning but >20-kt winds. Only one AM flight and no PM flight due to weather.

Date	Flight of Day	Time Engines On	Time Engines Off	Total Engine Time	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Dist (km)	Total Flight Dist (nm)	Start Obs.	End Obs.	Total Obs. Time	Flight Area	General Weather	Comments
19 Feb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No flight	Thunder-storms, heavy clouds, high winds	Unable to fly due to weather
Total Engine Time:				**18:36:00**	**Total Flown:**		**18:03:00**	**3213**	**1735**	**Total Obs Time**		**16:43:00**			**Add 3 hours (RT) for ferry time to and from Oxnard for aircraft**

Notes:

† Stayed 8 nm offshore due to U.S. Navy airspace restrictions. Short flight due to weight and fuel restrictions.

‡ Flew SW and W NAOPA but Beaufort 5+, so headed inshore. Flew zig-zag systematic from Carlsbad to Mt. Soledad 1–6 km (0.5 -3 nm) from coast in partial lee; flew S of Pt. Loma toward Silver Strand paralleling nearshore but airspace conflicts limited access.

Table 7. Summary of Flight Effort during SOCAL Marine Mammal Aerial Survey Monitoring March 30-1 April, 2011.

Date	Flight of Day	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Dist (km)	Total Flight Dist (nm)	Start Obs.	End Obs.	Total Obs. Time	Flight Area	General Weather	Comments
30-Mar	1	17:36	19:03	1:26	269	145	17:38	18:58	1:20	Line 5 NAOPA then fly W	Clear skies Bf 1-3	Late start due to plane delay in arriving at airport
31-Mar	1	8:50	11:41	2:51	521	281	8:54	11:36	2:42	S NAOPA and headed north	Clear skies Bf 0-1	
31-Mar	2	14:55	17:37	2:42	535	289	14:59	17:33	2:34	Central NAOPA	Clear skies Bf 1-3	
Total Flown:				**9:35:16**	**1865**	**1007**	**Total Obs. Time:**		**9:03:00**			

Table 8. Summary of Flight Effort during SOCAL Marine Mammal Aerial Survey Monitoring April 12-20, 2011.

Date	Flight of the Day	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Effort (km)	Total Flight Effort (nm)	On-Effort Start Time (hh:mm)	On-Effort End Time (hh:mm)	Total On-Effort Time	Flight Area	General Weather (Bf = Beaufort sea state)	Comments
12-Apr	1	11:34	17:37	6:03	1457.1	786.8	11:45	17:32	5:47	NAOPA	Heavy overcast Bf 1-5	Late start due to fog, SHOBA was hot, flew almost all of NAOPA survey lines
13-Apr	1	10:47	15:59	5:12	1181.0	637.7	10:50	15:49	4:59	NAOPA	Overcast Bf 2-5	Late start due to aircraft headphone equipment issue
14-Apr	1	9:10	14:24	5:14	1164.3	628.7	9:13	14:17	5:04	SOAR	Winds light and variable, high ceilings Bf 2-4	Flew all lines in SOAR
15-Apr	1	8:32	13:07	4:35	963.7	520.4	8:36	13:01	4:25	NAOPA	Bf 2-4	Good sighting visibility
15-Apr	2	14:36	17:14	2:38	557.9	301.3	14:39	17:08	2:29	NAOPA	Bf 2-4	Good sighting visibility
16-Apr	1	12:59	16:55	3:56	907.0	489.8	13:03	16:49	3:46	SOAR	Low haze Bf 3-6	Truncated survey lines due to high Bf, shut out of S end of SOAR by active SHOBA area
17-Apr	1	13:49	16:25	2:36	592.2	319.7	13:49	16:22	2:33	Silver Strand	Bf 3-5	Silver: effort directed at identifying animals (not abundance)
18-Apr	1	12:32	18:08	5:36	1317.6	711.4	12:35	18:02	5:27	NAOPA	Morning fog Bf 1-4	Late start due to fog
19-Apr	1	10:16	13:45	3:29	820.5	443.0	10:21	13:41	3:20	NAOPA	Bf 1-3	West side of NAOPA fogged in couldn't fly there
19-Apr	2	15:37	18:27	2:50	615.7	332.4	15:42	18:21	2:39	Silver Strand	Heavy overcast Bf 1-3	Flew all Silver Strand lines
20-Apr	1	10:03	15:58	5:54	1405.8	759.0	10:07	15:53	5:46	Silver Strand/ NAOPA	Heavy cloud cover Bf 2-4	North NAOPA socked in by fog, low clouds delayed departure
Total Flown:				**46:33**	**10983**	**5882**	**Total On-Effort Time:**		**44:15**			

Table 9. Flight Effort during SOCAL Marine Mammal Aerial Survey Monitoring 9-14 May 2011.

Date	Flight of Day	Time Engines On	Time Engines Off	Total Engine Time	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Dist (km)	Total Flight Dist (nm)	Start Obs.	End Obs.	Total Obs. Time	Flight Area	General Weather	Comments
09 May	1	14:55	17:18	2:23	15:03	17:16	2:13	394.4	212.8	15:07	17:10	2:03	NAOPA	Variable winds Bf 3-4	Small craft advisory
10 May	1	9:23	13:03	3:40	9:31	12:58	3:27	590.1	318.4	9:35	12:53	3:18	NAOPA	Clear skies Bf 2-5	
10 May	2	14:33	18:05	3:32	14:45	18:02	3:17	588.3	317.5	14:49	17:56	3:07	NAOPA	Clear skies Bf 2-5	SHOBA hot
11 May	1	9:34	11:09	1:35	9:42	11:05	1:23	248.0	133.9	9:46	11:01	1:15	NAOPA	Partly sunny Bf 2	Flew along underwater ridge
11 May	2	13:32	16:15	2:43	13:42	16:12	2:30	465.6	251.2	13:48	16:06	2:18	NAOPA	Partly sunny Bf 2-3	Dead humpback
12 May	1	10:18	14:22	4:04	10:22	14:17	3:55	770.6	415.9	10:26	14:10	3:44	SOAR	Patchy fog Bf 1-4	Late start due to fog, ceiling limited us to altitudes 800-1200 ft.
12 May	2	15:23	17:50	2:27	15:33	17:45	2:12	390.2	210.6	15:36	17:38	2:02	Silver Strand	Clear skies Bf 2-3	
13 May	1	13:16	17:19	4:03	13:23	17:14	3:51	681.3	367.6	13:28	17:09	3:41	NAOPA	Clear skies Bf 1-3	Late start due to heavy clouds
14 May	1	9:23	12:37	3:14	9:26	12:33	3:07	553.4	298.6	9:30	12:27	2:57	Silver Strand	Patchy fog Bf 2-3	Large pod of sperm whales
14 May	2	13:16	14:36	1:20	13:21	14:32	1:11	214.4	115.7	13:25	14:27	1:02	NAOPA	Partly cloudy Bf 1-3	
Total Engine Time:				**29:01:00**	**Total Flown:**		**27:01:00**	**4896.3**	**2642.2**	**Total Obs Time:**		**25:27:00**			

Table 10. Video recorded during 23-28 September SOCAL 2010 aerial monitoring surveys off San Diego, California.

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Sighting ID	Species	Video Notes	Taken By
SOCAL	SOCAL_2010Sept_23_SES_ Video_161914-162115_ID6_ CommonDolphinSp.	9/23/2010	16:19:14	16:21:15	0:02:01	6	Long-Beaked Common Dolphin	No voice on video, bird association	Mari Smultea
SOCAL	SOCAL_2010Sept_23_SES_ Video_162118-162244_ID6_ CommonDolphinSp.	9/23/2010	16:21:18	16:22:44	0:01:26	6	Long-Beaked Common Dolphin	No voice on video, bird association, animals spread out, inverted lunge	Mari Smultea
SOCAL	SOCAL_2010Sept_23_SES_ Video_162252-162416_ID6_ CommonDolphinSp.	9/23/2010	16:22:52	16:24:16	0:01:24	6	Long-Beaked Common Dolphin	No voice on video, bird association, inverted lunge	Mari Smultea
SOCAL	SOCAL_2010Sept_23_SES_ Video_162418-162429_ID6_ CommonDolphinSp.	9/23/2010	16:24:18	16:24:29	0:00:11	6	Long-Beaked Common Dolphin	No voice on video, 1 individual	Mari Smultea
SOCAL	SOCAL_2010Sept_26_SES_ Video_122055-122128_ IDBoat_Boat	9/26/2010	12:20:55	12:21:28	0:00:33	Boat	Boat		Bernd Würsig
SOCAL	SOCAL_2010Sept_26_SES_ Video_122421-122439_ IDBoat_Boat	9/26/2010	12:24:21	12:24:39	0:00:18	Boat	Boat	R/V Robert Gordon Sproul	Bernd Würsig
SOCAL	SOCAL_2010Sept_26_SES_ Video_122955-123021_ IDBoat_Boat	9/26/2010	12:29:55	12:30:21	0:00:26	Boat	Boat	R/V Robert Gordon Sproul	Bernd Würsig
SOCAL	SOCAL_2010Sept_26_SES_ Video_131518-133022_ID15_ CommonDolphinSp.	9/26/2010	13:15:18	13:30:22	0:15:04	15	Common Dolphin sp.	voice hard to understand, 1000 to 1200 individuals, bird association, dispersion 1-2, oriented at 090, group is more longer than horizontal, dispersion is 1-5, slow travel, no behavior changes seen	Bernd Würsig
SOCAL	SOCAL_2010Sept_26_SES_ Video_133347-133845_ID15_ CommonDolphinSp.	9/26/2010	13:33:47	13:38:45	0:04:58	15	Common Dolphin sp.	Same group as above, oriented at 090, dispersion 1-2, slow surface active travel, bird association, group in a slight triangle shape, oriented at 080, shape is a rectangle, dispersion 1-3, birds circling above dolphin	Bernd Würsig

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Sighting ID	Species	Video Notes	Taken By
SOCAL	SOCAL_2010Sept_26_SES_ Video_165617-165811_ID31_ CommonDolphinSp.	9/26/2010	16:56:17	16:58:11	0:01:54	31	Common Dolphin sp.	Animals all spread out, 80-100 individuals, calf seen,	Bernd Würsig
SOCAL	SOCAL_2010Sept_26_SES_ Video_165819-171548_ID31_ CommonDolphinSp.	9/26/2010	16:58:19	17:15:48	0:17:29	31	Common Dolphin sp.	Animals spread out, bird association, foraging, inverted swimming, 12 subgroups, surface active milling with birds, occasional lunging, spacing 1-3, one subgroup has roughly 20 animals, spacing 1-2, traveling to 120, second subgroup- surface active milling, spacing 1-2, roughly 10 individuals, spacing 1-12, inverted swim, porpoise lunging with birds, spacing 1-15, split up into 3 groups of 5, inverted swim, sighting number 30, spacing 1-18, 3rd subgroup- surface active milling, spinning, turning, spacing is 1-2, 5 animals in subgroup, inverting swim, lunging, porpoising, still surface active swim, birds swoop down with dolphin come to surface	Bernd Würsig
SOCAL	SOCAL_2010Sept_27_SES_ Video_105235-105354_ ID16_Risso's	9/27/2010	10:52:35	10:53:54	0:01:19	16	Risso's Dolphin	oriented 220, spacing 1-18, one animal is 30 body lengths, another animal 60 body lengths, 17 animals, slow travel	Bernd Würsig
SOCAL	SOCAL_2010Sept_27_SES_ Video_105413-110843_ ID16_Risso's	9/27/2010	10:54:13	11:08:43	0:14:30	16	Risso's Dolphin	spacing is 1-15, group really spread out, few animals 100 body lengths away, slow travel, foraging, bird flying by, 2 subgroups, 19 individuals, oriented at 220, line abreast formation, slow travel, 3 animals tightly grouped, in group spacing 1-2, otherwise 15-100 body lengths apart, animals not changing behavior, animals seem to be all coming together, animals turned to the west, spacing 1-3, slow travel, possible calf	Bernd Würsig

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Sighting ID	Species	Video Notes	Taken By
SOCAL	SOCAL_2010Sept_27_SES_ Video_122343-124044_ ID36_Risso's	9/27/2010	12:23:43	12:40:44	0:17:01	36	Risso's Dolphin	group of 2 trailing, with a group of 6-7 in the front, orientation 330, spacing 1-8, below surface, very tight in the front group, slow travel, 8 body lengths, orienting towards each other, spacing 1-4, oriented at 230, one animal in lead 100 body lengths away, logging, line abreast at surface, slow travel, spacing 1-7, most of group headed towards 230, resting at surface, spacing 1-1 in subgroup	Bernd Würsig
SOCAL	SOCAL_2010Sept_27_SES_ Video_150429-151406_ID61_ CommonDolphinSp.	9/27/2010	15:04:29	15:14:06	0:09:37	61	Common Dolphin sp.	birds on water, 1000 ft., foraging, dispersal within subgroup is 1-2, dolphin going in 2's and 3's chasing the birds, inverted swim, lunge and then dive	Bernd Würsig
SOCAL	SOCAL_2010Sept_27_SES_ Video_153115-155635_ID65_ CommonDolphinSp.	9/27/2010	15:31:15	15:56:35	0:25:20	65	Common Dolphin sp.	inverted swim, lunging, huge group of dolphin, roughly 1200 individuals, surface active travel, v shaped formation, orientation 350, fast travel, 1-2 spacing, boat 40 vessel lengths behind dolphins, group in front has 20 dolphins, oriented at 350, fast travel, spacing 1-2 for group in front, oblong formation, wider than long	Bernd Würsig
SOCAL	SOCAL_2010Sept_28_SES_ Video_125907-130846_ID12_ CommonDolphinSp.	9/28/2010	12:59:07	13:08:46	0:09:39	12	Common Dolphin sp.	bird association, two animals lunging together, spacing 1-2, 4-5 subgroups, milling with birds, 3 animals inverted lunge, multiple splash's, swimming inverted, competing for food, spacing 1-3, 2 inverted, one lunge turn, birds on water, split into 2 subgroups	Bernd Würsig
SOCAL	SOCAL_2010Sept_28_SES_ Video_132405-134500_ ID15_Risso's	9/28/2010	13:24:05	13:45:00	0:20:55	15	Risso's Dolphin	blow, blow, one animal, blow, heading is 7 o'clock, sub-surface, blow, traveling, heading towards 5 0'clock, slow travel below surface	Bernd Würsig
			Total Hours:		**2:24:05**				

Table 11. Video recorded during 14-19 February SOCAL 2011 aerial monitoring surveys off San Diego, California.

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011Feb_15_HDR_ Video_095256-095318_ID1_Gray	2/15/2011	9:52:56	9:53:18	0:00:22	1	Gray whale	2	2	Mother calf pair, slow travel	Bernd Würsig	Poor
SOCAL	SOCAL_2011Feb_15_HDR_ Video_095344-95459_ID1_Gray	2/15/2011	9:53:44	9:54:59	0:01:15	1	Gray whale	2	2	Mother calf pair, slow travel below surface, oriented at 150	Bernd Würsig	Fair
SOCAL	SOCAL_2011Feb_15_HDR_ Video_95601-95810_ID1_Gray	2/15/2011	9:56:01	9:58:10	0:02:09	1	Gray whale	2	2	Mother calf pair, slow travel, multiple blows, calf seen directly below mother	Bernd Würsig	Fair
SOCAL	SOCAL_2011Feb_15_HDR_ Video_095854-100010_ID1_Gray	2/15/2011	9:58:54	10:00:10	0:01:16	1	Gray whale	2	2	Shallow dives, mother calf pair, multiple blows,	Bernd Würsig	Fair
SOCAL	SOCAL_2011Feb_15_HDR_ Video_100143-101119_ID1_Gray	2/15/2011	10:01:43	10:11:19	0:09:36	1	Gray whale	2	2	Calf on moms back, multiple blows, traveling subsurface	Bernd Würsig	Good
SOCAL	SOCAL_2011Feb_15_HDR_ Video_104220-105141_ID5_Risso's	2/15/2011	10:42:20	10:51:41	0:09:21	5	Risso's dolphin	6	2	Traveling, dispersal 1-10, bird associated with group, possible feeding, sprinting, surface active mill, leaping	Bernd Würsig	Fair
SOCAL	SOCAL_2011Feb_15_HDR_ Video_110915-111413_ID5_Risso's	2/15/2011	11:09:15	11:14:13	0:04:58	5	Risso's dolphin	6	2	Very slow travel, one calf, line abreast	Bernd Würsig	Good

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011Feb_15_HDR_ Video_111414- 112457_ID5_Risso's	2/15/2011	11:14:14	11:24:57	0:10:43	5	Risso's dolphin	6	2	Very slow travel, one calf, line abreast, social	Bernd Würsig	Excellent
SOCAL	SOCAL_2011Feb_15_HDR_ Video_112500- 113854_ID5_Risso's	2/15/2011	11:25:00	11:38:54	0:13:54	5	Risso's dolphin	6	2	Slow travel, one calf, dove, multiple blows, calf seems to surface each time mother does	Bernd Würsig	Good
SOCAL	SOCAL_2011Feb_15_HDR_ Video_115741- 115828_ID6_Risso's	2/15/2011	11:57:41	11:58:28	0:00:47	6	Risso's dolphin	100	2	11 subgroups, one tight group touching each other, milling	Bernd Würsig	Good
SOCAL	SOCAL_2011Feb_15_HDR_ Video_115846- 115904_ID6_Risso's	2/15/2011	11:58:46	11:59:04	0:00:18	6	Risso's dolphin	100	2	Very short video, Rolling over, socializing, touching, milling	Bernd Würsig	Good
SOCAL	SOCAL_2011Feb_15_HDR_ Video_120000- 120121_ID6_Risso's	2/15/2011	12:00:00	12:01:21	0:01:21	6	Risso's dolphin	100	2	Focusing on one subgroup of animals, socializing, milling, in tight group	Bernd Würsig	Good
SOCAL	SOCAL_2011Feb_15_HDR_ Video_120138- 120207_ID6_Risso's	2/15/2011	12:01:38	12:02:07	0:00:29	6	Risso's dolphin	100	2	Focusing on one subgroup of animals, socializing, milling, in tight group, 3 facing each other and came together	Bernd Würsig	Good

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011Feb_15_HDR_ Video_1200216-120623_ID6_Risso's	2/15/2011	12:02:16	12:06:23	0:04:07	6	Risso's dolphin	100	2	Group of 21 individuals, line abreast, socializing, part of group milling, tail slap, slow travel	Bernd Würsig	Good
SOCAL	SOCAL_2011Feb_15_HDR_ Video_151224-152241_ID15_Risso's	2/15/2011	15:12:24	15:22:41	0:10:17	15	Risso's dolphin	8	2	Slow travel, groups of 4, 4 and 2 figuration	Bernd Würsig	Fair
SOCAL	SOCAL_2011Feb_17_HDR_ Video_155621-155757_ID38_Gray	2/17/2011	15:56:21	15:57:57	0:01:36	38	Gray whale	1	1	One individual seen traveling slowly at the surface	Mari Smultea	Fair
SOCAL	SOCAL_2011Feb_17_HDR_ Video_160943-161643_ID38_Gray	2/17/2011	16:09:43	16:16:43	0:07:00	38	Gray whale	1	1	Traveling slowly at surface	Mari Smultea	Fair
SOCAL	SOCAL_2011Feb_17_HDR_ Video_161648-161909_ID38_Gray	2/17/2011	16:16:48	16:19:09	0:02:21	38	Gray whale	1	1	Slow travel at the surface	Mari Smultea	Fair
			Total Hours:		**1:11:13**							

Table 12. Video recorded during 30 March-1 April SOCAL 2011 aerial monitoring surveys off San Diego, California.

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011March_30_HDR_Video_183738-183809_ID5_Commonsp.	3/30/2011	18:37:38	18:38:09	0:00:31	5	Common Dolphin sp.	18	2	Milling, dispersion 1-3, birds close to water diving, swimming in tight circles	Bernd Würsig	Good
SOCAL	SOCAL_2011March_30_HDR_Video_183903-183955_ID5_Commonsp.	3/30/2011	18:39:03	18:39:55	0:00:52	5	Common Dolphin sp.	18	2	Dispersion 1-2, bird association, surface-active mill, a dolphin seen spinning	Bernd Würsig	Excellent
SOCAL	SOCAL_2011March_30_HDR_Video_184031-184139_ID5_Commonsp.	3/30/2011	18:40:31	18:41:39	0:01:08	5	Common Dolphin sp.	18	2	Dispersion 1-3, birds seen diving	Bernd Würsig	Fair
SOCAL	SOCAL_2011March_30_HDR_Video_184232-184303_ID5_Commonsp.	3/30/2011	18:42:32	18:43:03	0:00:31	5	Common Dolphin sp.	18	2	Inverted swimming, bird association	Bernd Würsig	Good
SOCAL	SOCAL_2011March_30_HDR_Video_184359-184400_ID5_Commonsp.	3/30/2011	18:43:59	18:44:00	0:00:01	5	Common Dolphin sp.	18	2	Video not long enough	Bernd Würsig	Poor
SOCAL	SOCAL_2011March_30_HDR_Video_184449-184531_ID5_Commonsp.	3/30/2011	18:44:49	18:45:31	0:00:42	5	Common Dolphin sp.	18	2	Inverted swimming, bird association, dispersion 1-4	Bernd Würsig	Good
SOCAL	SOCAL_2011March_31_HDR_Video_093730-100535_ID4_Risso's	3/31/2011	9:37:30	10:05:35	0:28:05	4	Risso's dolphin	18	1	Staggered line abreast, 17 animals, slow travel, dispersal 1-4	Bernd Würsig	Good

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011March_31_HDR_Video_102217-103531_ID4_Risso's	3/31/2011	10:22:17	10:35:31	0:13:14	4	Risso's dolphin	18	1	Tight group, staggered line abreast, vessel seen 50 vessel lengths away from dolphin, common dolphin seen 100 body lengths away swimming in opposite direction	Bernd Würsig	Good
SOCAL	SOCAL_2011March_31_HDR_Video_104835-105726_ID7_Minke	3/31/2011	10:48:35	10:57:26	0:08:51	7	Minke whale	2	0	Multiple blows, 2 animals, slow travel, one whale inverted swim, other whale ~3 body lengths away	Bernd Würsig	Fair
SOCAL	SOCAL_2011March_31_HDR_Video_112109-113241_ID9_LBCommon	3/31/2011	11:21:09	11:32:41	0:11:32	9	Long-beaked Common Dolphin	35	0	Medium travel, possible calf see, dispersion 1-6	Bernd Würsig	Fair
SOCAL	SOCAL_2011March_April01_HDR_Video_092241-092640_ID23_Risso's	4/1/2011	9:22:41	9:26:40	0:03:59	23	Risso's Dolphin	20	2	4 individuals, slow travel, dispersal 15-40, milling, one pair	Dan Engelhaupt	Fair
SOCAL	SOCAL_2011March_April01_HDR_Video_092654-092822_ID23-24_NRWDolphin	4/1/2011	9:26:54	9:28:22	0:01:28	23,24	NRW Dolphins	8	2	2-3 Risso's with 5 NRWD	Dan Engelhaupt	Fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011March_April01_HDR _Video_093500-093944_ID24_NRWDolphin	4/1/2011	9:35:00	9:39:44	0:04:44	24	NRW Dolphins	8	2	tight group, dispersal 1-1, behavior has not changed throughout video, foraging dives, possible competition for food	Dan Engelhaupt	Poor
SOCAL	SOCAL_2011March_April01_HDR _Video_093948-094010_ID24_Risso's-NRWDolphin	4/1/2011	9:39:48	9:40:10	0:00:22	24	Risso's Dolphin, NRW Dolphins	8 NRWD, 20 Risso's	2	group of 4, video too short	Dan Engelhaupt	Fair
SOCAL	SOCAL_2011March_April01_HDR _Video_094043-095111_ID24_Risso's-NRWDolphin	4/1/2011	9:40:43	9:51:11	0:10:28	24	Risso's Dolphin, NRW Dolphins	8 NRWD, 20 Risso's	2	foraging, 7 NRWD, dispersal 3-7, NRWD interspersed with Risso's, 3 Risso's 2 NRWD	Dan Engelhaupt	Good
SOCAL	SOCAL_2011March_April01_HDR _Video_100142-101003_ID28-31_Risso's-NRWDolphin-Gray	4/1/2011	10:01:42	10:10:03	0:08:21	28,29,30, 31	Risso's Dolphin, NRW Dolphins, Gray whale	20 Risso's, 25 NRWD, 3 Gray	1	Single Risso's surface-active travel, 3 gray whales, poss. calf on back of adult, slow travel, a lot of barnacles seen on one, sub-group of Risso's ~40 body lengths from single Risso's	Dan Engelhaupt	Good
			Total Hours:		**1:34:49**							

Table 13. Video recorded during 12- 20 April SOCAL 2011 aerial monitoring surveys off San Diego, California.

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_12_HDR_ Video_120047- 120557_ID1_Commonsp.	4/12/2011	12:00:47	12:05:57	0:05:10	1	Common dolphin sp.	440	3	Surface-active travel, angle 120, altitude 700 ft. , animals rarely seen in video, bird association, dispersal 1-5	Bernd Würsig	fair
SOCAL	SOCAL_2011April_12_HDR_ Video_124153- 125438_ID4_Risso's	4/12/2011	12:41:53	12:54:38	0:12:45	4	Risso's dolphin	25	2	2 subgroups heading in same direction, dispersal 1-5, slow travel, staggered line abreast, 1500 ft., .5 mile from shore	Bernd Würsig	fair
SOCAL	SOCAL_2011April_12_HDR_ Video_160255- 163327_ID11_Fin	4/12/2011	16:02:55	16:33:27	0:30:32	11	Fin whale	2	3	2 animals 3 body lengths away, asynchronous and sometimes synchronous surfacing times, medium travel, multiple blows	Bernd Würsig	good
SOCAL	SOCAL_2011April_12_HDR_ Video_105902- 113353_ID3_Gray	4/13/2011	10:59:52	11:33:53	0:34:01	3	Gray whale	3	3	Traveling subsurface, multiple blows	Bernd Würsig	fair
SOCAL	SOCAL_2011April_13_HDR_ Video_113649- 114751_ID4_Risso's	4/13/2011	11:36:49	11:47:51	0:11:02	4	Risso's dolphin	24	3	Staggered line abreast, no audio during video	Bernd Würsig	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_13_HDR_Video_141659-142351_ID15_Risso's	4/13/2011	14:16:59	14:23:51	0:06:52	15	Risso's dolphin	75	3	Dispersal 1-2, slow travel	Bernd Würsig	fair
SOCAL	SOCAL_2011April_13_HDR_Video_150217-151444_ID18_Commonsp.	4/13/2011	15:02:17	15:14:44	0:12:27	18	Common dolphin sp.	450	3	Surface-active mill, splashing, bird association, zigzagging seen	Bernd Würsig	fair
SOCAL	SOCAL_2011April_14_HDR_Video_114902-114958_ID18_Fin	4/14/2011	11:49:02	11:49:58	0:00:56	10	Fin whale	1	3	Animal never seen, one whale, Risso's seen in distance	Bernd Würsig	poor
SOCAL	SOCAL_2011April_14_HDR_Video_115324-115431_ID11_Risso's	4/14/2011	11:53:24	11:54:31	0:01:07	11	Risso's dolphin	60	3	Very spread out, animals rarely seen in video	Bernd Würsig	poor
SOCAL	SOCAL_2011April_15_HDR_Video_095453-095512_ID5_Minke	4/15/2011	9:54:53	9:55:12	0:00:19	5	Minke whale	2	2	Animal sub-surface, not seen in video	Bernd Würsig	poor
SOCAL	SOCAL_2011April_15_HDR_Video_095933-100009_ID5_Minke	4/15/2011	9:59:33	10:00:09	0:00:36	5	Minke whale	2	2	never seen in video	Bernd Würsig	poor
SOCAL	SOCAL_2011April_15_HDR_Video_100226-100316_ID5_Minke	4/15/2011	10:02:26	10:03:16	0:00:50	5	Minke whale	2	2	never seen in video	Bernd Würsig	poor
SOCAL	SOCAL_2011April_15_HDR_Video_101631-102021_ID5_Minke	4/15/2011	10:16:31	10:20:21	0:03:50	5	Minke whale	2	2	scat seen in video, one animal, arch dive, 2 other minke's seen 1.25 miles ahead,	Bernd Würsig	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_15_HDR_Video_102028-102947_ID5_Minke	4/15/2011	10:20:28	10:29:47	0:09:19	5	Minke whale	2	2	no blow rise, poss. calf in front, dispersal 1-1, slow travel, multiple blows, social mill	Bernd Würsig	good
SOCAL	SOCAL_2011April_15_HDR_Video_112502-114040_ID7_Risso's	4/15/2011	11:25:02	11:40:40	0:15:38	7	Risso's dolphin	19	3	rest/slow travel, 800 feet altitude	Bernd Würsig	fair
SOCAL	SOCAL_2011April_15_HDR_Video_154642-160219_ID19_Risso's	4/15/2011	15:46:42	16:02:19	0:15:37	19	Risso's dolphin	24	3	rest/slow travel, dispersal 1-10	Bernd Würsig	fair
SOCAL	SOCAL_2011April_16_HDR_Video_151809-152922_ID12_Fin	4/16/2011	15:18:09	15:29:22	0:11:13	12	Fin whale	1	4	medium to fast travel, multiple blows, traveled over 3km since first observed	Mari Smultea	poor
SOCAL	SOCAL_2011April_16_HDR_Video_152927-153009_ID12_Fin	4/16/2011	15:29:27	15:30:09	0:00:42	12	Fin whale	1	4	animal rarely seen, blow	Mari Smultea	poor
SOCAL	SOCAL_2011April_16_HDR_Video_153058-163333_ID12_Fin	4/16/2011	15:30:58	15:33:33	0:02:35	12	Fin whale	1	4	medium travel, subsurface, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_16_HDR_Video_153335-153537_ID12_Fin	4/16/2011	15:33:35	15:35:37	0:02:02	12	Fin whale	1	4	rarely seen, traveling to the 3 o'clock	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_131749-131809_ID3_Risso's	4/18/2011	13:17:49	13:18:09	0:00:20	3	Risso's dolphin	7	2	2 Risso's seen at the end of the video traveling	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_131813-132519_ID3_Risso's	4/18/2011	13:18:13	13:25:19	0:07:06	3	Risso's dolphin	7	2	Milling	Mari Smultea	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_18_HDR_ Video_132542- 133727_ID3_Risso's	4/18/2011	13:25:42	13:37:27	0:11:45	3	Risso's dolphin	7	2	2 subgroups, traveling line abreast, *Tursiops* in front of Risso's but not seen in video, socializing	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_ Video_133745- 134141_ID3_Risso's	4/18/2011	13:37:45	13:41:41	0:03:56	3	Risso's dolphin	7	2	Social travel	Mari Smultea	good
SOCAL	SOCAL_2011April_18_HDR_ Video_134227- 134508_ID3_Risso's	4/18/2011	13:42:27	13:45:08	0:02:41	3	Risso's dolphin	7	2	Slow travel, social, tight line abreast	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_ Video_134514- 134813_ID3_Risso's	4/18/2011	13:45:14	13:48:13	0:02:59	3	Risso's dolphin	7	2	2 subgroups separated by 15 body lengths, traveling	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_ Video_134823- 134906_ID3_Risso's	4/18/2011	13:48:23	13:49:06	0:00:43	3	Risso's dolphin	7	2	Traveling	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_ Video_134929- 135038_ID3_Risso's	4/18/2011	13:49:29	13:50:38	0:01:09	3	Risso's dolphin	7	2	Staggered line abreast, traveling	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_ Video_135053- 135103_ID3_Risso's	4/18/2011	13:50:53	13:51:03	0:00:10	3	Risso's dolphin	7	2	Seen traveling at surface, very short video	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_ Video_141752- 141920_ID5_Risso's	4/18/2011	14:17:52	14:19:20	0:01:28	5	Risso's dolphin	12	1	Traveling staggered line abreast, video is far from animals and not clear	Mari Smultea	poor

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_18_HDR_Video_142344-142422_ID5_Risso's	4/18/2011	14:23:44	14:24:22	0:00:38	5	Risso's dolphin	12	1	Group seen traveling at surface, video very short and plane in the way	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_142845-142947_ID5_Risso's	4/18/2011	14:28:45	14:29:47	0:01:02	5	Risso's dolphin	12	1	Slow travel line abreast	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_143131-143240_ID5_Risso's	4/18/2011	14:31:31	14:32:40	0:01:09	5	Risso's dolphin	12	1	Line abreast, slow travel	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_143323-143514_ID5_Risso's	4/18/2011	14:33:23	14:35:14	0:01:51	5	Risso's dolphin	12	1	Slow travel line abreast	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_143548-143819_ID5_Risso's	4/18/2011	14:35:48	14:38:19	0:02:31	5	Risso's dolphin	12	1	Surface-active mill	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_144039-144122_ID5_Risso's	4/18/2011	14:40:39	14:41:22	0:00:43	5	Risso's dolphin	12	1	Surface-active mill, 6 animals seen in video	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_144321-144715_ID5_Risso's	4/18/2011	14:43:21	14:47:15	0:03:54	5	Risso's dolphin	12	1	Same group, surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_144843-144922_ID5_Risso's	4/18/2011	14:48:43	14:49:22	0:00:39	5	Risso's dolphin	12	1	Same group, surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_145000-145018_ID5_Risso's	4/18/2011	14:50:00	14:50:18	0:00:18	5	Risso's dolphin	12	1	Traveling subsurface	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_145107-145151_ID5_Risso's	4/18/2011	14:51:07	14:51:51	0:00:44	5	Risso's dolphin	12	1	Same group, surface-active mill	Mari Smultea	poor

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_18_HDR_Video_145201-145319_ID5_Risso's	4/18/2011	14:52:01	14:53:19	0:01:18	5	Risso's dolphin	12	1	Surface-active mill, same group as above	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_145402-145504_ID5_Risso's	4/18/2011	14:54:02	14:55:04	0:01:02	5	Risso's dolphin	12	1	Same group as above	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_145537-145620_ID5_Risso's	4/18/2011	14:55:37	14:56:20	0:00:43	5	Risso's dolphin	12	1	Same group as above, Surface-active mill	Mari Smultea	good
SOCAL	SOCAL_2011April_18_HDR_Video_145631-145713_ID5_Risso's	4/18/2011	14:56:31	14:57:13	0:00:42	5	Risso's dolphin	12	1	Same group as above, Surface-active mill, U shape formation	Mari Smultea	good
SOCAL	SOCAL_2011April_18_HDR_Video_145746-145949_ID5_Risso's	4/18/2011	14:57:46	14:59:49	0:02:03	5	Risso's dolphin	12	1	Same group as above, Surface-active mill	Mari Smultea	good
SOCAL	SOCAL_2011April_18_HDR_Video_150121-150153_ID5_Risso's	4/18/2011	15:01:21	15:01:53	0:00:32	5	Risso's dolphin	12	1	Same group as above, Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_150229-150307_ID5_Risso's	4/18/2011	15:02:29	15:03:07	0:00:38	5	Risso's dolphin	12	1	Same group as above, Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_150319-150405_ID5_Risso's	4/18/2011	15:03:19	15:04:05	0:00:46	5	Risso's dolphin	12	1	Same group as above, Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_150440-150610_ID5_Risso's	4/18/2011	15:04:40	15:06:10	0:01:30	5	Risso's dolphin	12	1	Same group as above, Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_170026-170052_ID15_Bottlenose	4/18/2011	17:00:26	17:00:52	0:00:26	15	Bottlenose dolphin	32	2	Surface-active mill	Mari Smultea	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_18_HDR_Video_170142-170315_ID15_Bottlenose	4/18/2011	17:01:42	17:03:15	0:01:33	15	Bottlenose dolphin	32	2	Surface-active mill, same group as above	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_170520-170610_ID15_Bottlenose	4/18/2011	17:05:20	17:06:10	0:00:50	15	Bottlenose dolphin	32	2	Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_170650-170737_ID15_Bottlenose	4/18/2011	17:06:50	17:07:37	0:00:47	15	Bottlenose dolphin	32	2	Surface-active mill, same group as above	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_170739-170821_ID15_Bottlenose	4/18/2011	17:07:39	17:08:21	0:00:42	15	Bottlenose dolphin	32	2	Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_171040-171205_ID15_Bottlenose	4/18/2011	17:08:44	17:10:29	0:01:45	15	Bottlenose dolphin	32	2	Surface-active mill, same group as above	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_171040-171205_ID15_Bottlenose	4/18/2011	17:10:40	17:12:05	0:01:25	15	Bottlenose dolphin	32	2	Surface-active mill	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_174625-174655_ID19_Common	4/18/2011	17:46:25	17:46:55	0:00:30	19	Common dolphin sp.	105	2	Sprinting, surface-active travel, bird association	Mari Smultea	fair
SOCAL	SOCAL_2011April_18_HDR_Video_174657-174742_ID19_Common	4/18/2011	17:46:57	17:47:42	0:00:45	19	Common dolphin sp.	105	2	Zigzag swim, bird association, surface-active travel	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_174815-174828_ID19_Common	4/18/2011	17:48:15	17:48:28	0:00:13	19	Common dolphin sp.	105	2	Bird association, surface-active travel, unidentified splash seen	Mari Smultea	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_18_HDR_Video_174902-174923_ID19_Common	4/18/2011	17:49:02	17:49:23	0:00:21	19	Common dolphin sp.	105	2	Bird association, surface-active travel, airplane in way of video	Mari Smultea	poor
SOCAL	SOCAL_2011April_18_HDR_Video_174945-175051_ID19_Common	4/18/2011	17:49:45	17:50:51	0:01:06	19	Common dolphin sp.	105	2	Bird association, surface-active travel	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_103913-104027_ID2_Fin	4/19/2011	10:39:13	10:40:27	0:01:14	2	Fin whale	3	2	Animal seen once, surfaced, blew and dove	Mari Smultea	poor
SOCAL	SOCAL_2011April_19_HDR_Video_104119-104504_ID2_Fin	4/19/2011	10:41:19	10:45:04	0:03:45	2	Fin whale	3	2	Animals rarely seen in video	Mari Smultea	poor
SOCAL	SOCAL_2011April_19_HDR_Video_105450-105550_ID2_Fin	4/19/2011	10:54:50	10:55:50	0:01:00	2	Fin whale	3	2	2 adults seen subsurface, dispersal less than one	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_105601-110501_ID2_Fin	4/19/2011	10:56:01	11:05:11	0:09:10	2	Fin whale	3	2	3 animals seen traveling subsurface, defecation	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_114701-114848_ID5_Common	4/19/2011	11:47:01	11:48:48	0:01:47	5	Long-Beaked Common dolphin	350	1	Surface-active travel, foraging, inverted swimming, sprinting, bird association	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_114855-115339_ID5_Common	4/19/2011	11:48:55	11:53:39	0:04:44	5	Long-Beaked Common dolphin	350	1	Surface-active travel, foraging, inverted swimming, sprinting, bird association	Mari Smultea	good

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_19_HDR_Video_115506-115627_ID5_Common	4/19/2011	11:55:06	11:56:27	0:01:21	5 Flight 1	Long-Beaked Common dolphin	350	1	Surface-active travel, foraging, inverted swimming, sprinting, bird association	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_121140-122605_ID7_Risso's	4/19/2011	12:11:40	12:26:05	0:14:25	7	Risso's dolphin	25	3	Medium travel staggered line abreast, milling	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_155644-155843_ID12_Fin	4/19/2011	15:56:44	15:58:43	0:01:59	12	Fin whale	1	2	Seen traveling subsurface, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_171155-172300_ID12_Fin	4/19/2011	15:59:44	16:01:19	0:01:35	12	Fin whale	1	2	Seen traveling subsurface, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_171155-172300_ID16_Common	4/19/2011	17:11:55	17:23:00	0:11:05	16	Common dolphin sp.	1000	3	Apparent foraging, splashing, bird association, zig zag swimming, surface-active travel	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_172310-172551_ID16_Common	4/19/2011	17:23:10	17:25:51	0:02:41	5 Flight 2	Short-Beaked Common Dolphin	1000	3	Surface-active travel, bird association, loose aggregation	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_175155-175329_ID18_Risso's	4/19/2011	17:51:55	17:53:29	0:01:34	18	Risso's dolphin	24	3	Fast travel at surface	Mari Smultea	fair
SOCAL	SOCAL_2011April_19_HDR_Video_175340-180236_ID18_Risso's	4/19/2011	17:53:40	18:02:36	0:08:56	18	Risso's dolphin	24	3	Fast travel at surface, 1000 feet altitude	Mari Smultea	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_20_HDR_Video_101319-101759_ID1_Common	4/20/2011	10:13:19	10:17:59	0:04:40	1	Long-Beaked Common dolphin	45	2	2-3 subgroups, fast travel	Mari Smultea	poor
SOCAL	SOCAL_2011April_20_HDR_Video_103151-103421_ID4_Blue	4/20/2011	10:31:51	10:34:21	0:02:30	4	Blue whale	2	2	2 animals seen traveling, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_103951-104148_ID4_Blue	4/20/2011	10:39:51	10:41:48	0:01:57	4	Blue whale	2	2	Multiple blows, 2 animals seen, defecation	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_104453-104639_ID4_Blue	4/20/2011	10:44:53	10:46:39	0:01:46	4	Blue whale	2	2	Two animals seen slow travel subsurface	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_105538-105755_ID4_Blue	4/20/2011	10:55:38	10:57:55	0:02:17	4	Blue whale	2	2	Two animals seen slow travel subsurface	Mari Smultea	good
SOCAL	SOCAL_2011April_20_HDR_Video_110853-111125_ID4_Blue	4/20/2011	11:08:53	11:11:25	0:02:32	4	Blue whale	2	2	One animal visible subsurface, slow travel with multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_111426-111726_ID4_Blue	4/20/2011	11:14:26	11:17:26	0:03:00	4	Blue whale	2	2	One animal traveling subsurface, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_124517-124910_ID8_Blue	4/20/2011	12:45:17	12:49:10	0:03:53	8	Blue whale	1	3	Seen slow travel subsurface, multiple blows,	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_125434-130141_ID8_Blue	4/20/2011	12:54:34	13:01:41	0:07:07	8	Blue whale	1	3	Seen slow travel subsurface, multiple blows,	Mari Smultea	fair

Navy Range	Video Name	Date	Start Time	End Time	Total Video (hr:min:sec)	Daily Sighting ID	Species	Best Group Size	Beaufort sea state	Video Notes	Taken By	Video Utility/ Quality[a]
SOCAL	SOCAL_2011April_20_HDR_Video_130737-131046_ID8_Blue	4/20/2011	13:07:37	13:10:46	0:03:09	8	Blue whale	1	3	Seen traveling subsurface, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_131357-131449_ID8_Blue	4/20/2011	13:13:57	13:14:49	0:00:52	8	Blue whale	1	3	Very short video, multiple blows while whale traveling	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_131957-132333_ID8_Blue	4/20/2011	13:19:57	13:23:33	0:03:36	8	Blue whale	1	3	Traveling, multiple blows	Mari Smultea	fair
SOCAL	SOCAL_2011April_20_HDR_Video_132724-132914_ID8_Blue	4/20/2011	13:27:24	13:29:14	0:01:50	8	Blue whale	1	3	seen traveling subsurface, multiple blows	Mari Smultea	good
SOCAL	SOCAL_2011April_20_HDR_Video_135008-135511_ID9_Risso's	4/20/2011	13:50:08	13:55:11	0:05:03	9	Risso's dolphin	22	3	medium travel, dispersal 1-3, line abreast, oriented at 320, 800 feet altitude	Mari Smultea	good
			Total Hours:		**5:15:47**							

Table 14. Video recorded during 9-14 May SOCAL 2011 aerial monitoring surveys off San Diego, California.

Navy Range	Video Name	Date (day mo yr)	Start Time (hr:min:sec)	End Time (hr:min:sec)	Total Video (hr:min:sec)	Daily Sighting ID#	Species	Group Size (best estim.)	Beaufort sea state	Taken by?	Video Utility/ Quality[a]	General Description of Video Content
SOCAL	SOCAL_2011May_9_HDR_ Video_154828- 155054_ID4_Fin	5/9/2011	15:48:28	15:50:54	0:02:26	4	Fin whale	1	3	Mari Smultea	fair	Audio is very hard to hear. Very short video, with little behavior. One whale seen subsurface then dove. Surfaced and blew, and dove again.
SOCAL	SOCAL_2011May_9_HDR_ Video_160130- 160435_ID3_Blue	5/9/2011	16:01:30	16:04:35	0:03:05	3	Blue whale	1	3	Mari Smultea	fair	Audio is very hard to hear. One whale seen traveling and dove.
SOCAL	SOCAL_2011May_9_HDR_ Video_161737- 162057_ID3_Blue	5/9/2011	16:17:37	16:20:57	0:03:20	3	Blue whale	1	3	Mari Smultea	fair	Audio is very hard to hear. Whale surfaced and dove.
SOCAL	SOCAL_2011May_9_HDR_ Video_162611- 162733_ID3_Blue	5/9/2011	16:26:11	16:27:33	0:01:22	3	Blue whale	1	3	Mari Smultea	poor	Audio is very hard to hear. Whale seen traveling at surface, blew, and dove.
SOCAL	SOCAL_2011May_9_HDR_ Video_163127- 163526_ID3_Blue	5/9/2011	16:31:27	16:35:26	0:03:59	3	Blue whale	1	3	Mari Smultea	fair	Audio is very hard to hear. Whale seen traveling subsurface, multiple surfacings with blows. Whale seen resting at surface, fluke up and dove.

Navy Range	Video Name	Date (day mo yr)	Start Time (hr:min:sec)	End Time (hr:min:sec)	Total Video (hr:min:sec)	Daily Sighting ID#	Species	Group Size (best estim.)	Beaufort sea state	Taken by?	Video Utility/ Quality[a]	General Description of Video Content
SOCAL	SOCAL_2011May_9_HDR_ Video_165143-165502_ID3_Blue	5/9/2011	16:51:43	16:55:02	0:03:19	3	Blue whale	1	3	Mari Smultea	fair	Audio is very hard to hear.
SOCAL	SOCAL_2011May_10_HDR_ Video_094256-095416_ID2_Blue	5/10/2011	9:42:56	9:54:16	0:11:20	2	Blue whale	1	2	Mari Smultea	excellent	Bottlenose dolphins swimming and touching rostrum of blue whale.
SOCAL	SOCAL_2011May_10_HDR_ Video_095452-100458_ID2_Blue	5/10/2011	9:54:52	10:04:58	0:10:06	2	Blue whale	1	2	Mari Smultea	excellent	Bottlenose dolphins swimming and touching rostrum of blue whale.
SOCAL	SOCAL_2011May_10_HDR_ Video_100616-104735_ID2-4_Blue/Fin/Bottlenose	5/10/2011	10:06:16	10:47:35	0:41:19	2	Blue whale/ Fin whale	2 blue/ 1 fin	2	Mari Smultea	excellent	2 blue whales seen with large bottlenose dolphins. Blue whale seen bubble blasting when dolphins near whale. Fin whale seen 30 body lengths from blue whales
SOCAL	SOCAL_2011May_10_HDR_ Video_105015-111008_ID2_Blue/Risso's	5/10/2011	10:50:15	11:10:08	0:19:53	2, 7	Blue whale/ Risso's	1	2	Mari Smultea	excellent	First half of video blue whale, then focuses on Risso's dolphin behavior
SOCAL	SOCAL_2011May_11_HDR_ Video_100231-100449_ID2_Blue	5/11/2011	10:02:31	10:04:49	0:02:18	1	Blue whale	1	2	Mari Smultea	fair	Multiple surfacings with blows, short video

Navy Range	Video Name	Date (day mo yr)	Start Time (hr:min:sec)	End Time (hr:min:sec)	Total Video (hr:min:sec)	Daily Sighting ID#	Species	Group Size (best estim.)	Beaufort sea state	Taken by?	Video Utility/ Quality[a]	General Description of Video Content
SOCAL	SOCAL_2011May_11_HDR_Video_101312-101825_ID2_Blue	5/11/2011	10:13:12	10:18:25	0:05:13	2	Blue whale	2	2	Mari Smultea	fair	2 blue whales synchronized but not seen in video together. Roughly 12 body lengths apart
SOCAL	SOCAL_2011May_11_HDR_Video_102450-102959_ID2_Blue	5/11/2011	10:24:50	10:29:59	0:05:09	2	Blue whale	1	2	Mari Smultea	fair	Multiple surfacings with blows
SOCAL	SOCAL_2011May_11_HDR_Video_103625-103822_ID2_Blue	5/11/2011	10:36:25	10:38:22	0:01:57	2	Blue whale	1	2	Mari Smultea	fair	Multiple surfacings with blows
SOCAL	SOCAL_2011May_11_HDR_Video_104000-104203_ID2_Blue	5/11/2011	10:40:00	10:42:03	0:02:03	2	Blue whale	1	2	Mari Smultea	fair	Short video, sailboat seen in vicinity of whale
SOCAL	SOCAL_2011May_11_HDR_Video_104652-104852_ID2_Blue	5/11/2011	10:46:52	10:48:52	0:02:00	2	Blue whale	1	2	Mari Smultea	fair	Short video, multiple bows and surfacings
SOCAL	SOCAL_2011May_11_HDR_Video_105210-105400_ID2_Blue	5/11/2011	10:52:10	10:54:00	0:01:50	2	Blue whale	1	2	Mari Smultea	good	Blue whale seen tail popping and a bubble blast, multiple blows
SOCAL	SOCAL_2011May_11_HDR_Video_140710-142216_ID6-7_Risso's/Bottlenose	5/11/2011	14:07:10	14:22:16	0:15:06	6, 7	Risso's dolphin /Bottle-nose	32	3	Mari Smultea	good	2 groups of Risso's dolphins separated by 8 bottlenose dolphins
SOCAL	SOCAL_2011May_11_HDR_Video_142219-142440_ID6_Risso's/Bottle nose	5/11/2011	14:22:19	14:24:40	0:02:21	6, 7	Risso's dolphin	32	3	Mari Smultea	fair	2 groups of Risso's dolphins separated by 8 bottlenose dolphins
SOCAL	SOCAL_2011May_11_HDR_Video_150529-151358_ID9_Risso's	5/11/2011	15:05:29	15:13:58	0:08:29	9	Risso's dolphin	7	2	Mari Smultea	good	dolphins resting and diving

Navy Range	Video Name	Date (day mo yr)	Start Time (hr:min:sec)	End Time (hr:min:sec)	Total Video (hr:min:sec)	Daily Sighting ID#	Species	Group Size (best estim.)	Beaufort sea state	Taken by?	Video Utility/ Quality[a]	General Description of Video Content
SOCAL	SOCAL_2011May_11_HDR_ Video_151450- 151547_ID9_Risso's	5/11/2011	15:14:50	15:15:47	0:00:57	9	Risso's dolphin	7	2	Mari Smultea	fair	very short video, Risso's seen resting
SOCAL	SOCAL_2011May_11_HDR_ Video_151625- 151754_ID9_Risso's	5/11/2011	15:16:25	15:17:54	0:01:29	9	Risso's dolphin	7	2	Mari Smultea	fair	Very short video, Risso's seen resting
SOCAL	SOCAL_2011May_11_HDR_ Video_151911- 152511_ID9_Risso's	5/11/2011	15:19:11	15:25:11	0:06:00	9	Risso's dolphin	7	2	Mari Smultea	fair	Dolphins seen staying down longer than usual, seen resting at surface
SOCAL	SOCAL_2011May_11_HDR_ Video_153112- 154103_ID10_Risso's	5/11/2011	15:31:12	15:41:03	0:09:51	10	Risso's dolphin	4	3	Mari Smultea	good	1300 feet, all subsurface, seen fast travel fanning out and then slowing down
SOCAL	SOCAL_2011May_12_HDR_ Video_163536- 164336_ID11_Fin	5/12/2011	16:35:36	16:43:36	0:08:00	11	Fin whale	1	2	Mari Smultea	poor	Whale not seen in video very much, few blows seen
SOCAL	SOCAL_2011May_12_HDR_ Video_165831- 172447_ID12_Risso's	5/12/2011	16:58:31	17:24:47	0:26:16	13	Risso's dolphin	14	3	Mari Smultea	fair	Risso's seen fast travel with social behaviors
SOCAL	SOCAL_2011May_13_HDR_ Video_140509- 142208_ID5_Fin	5/13/2011	14:05:09	14:22:08	0:16:59	5	Fin whale	2	2	Mari Smultea	good	2 Fin whales traveling subsurface, lined up 10 body lengths apart
SOCAL	SOCAL_2011May_13_HDR_ Video_142628- 142748_ID5_Fin	5/13/2011	14:26:28	14:27:48	0:01:20	5	Fin whale	2	2	Mari Smultea	poor	Heading 060, whale blew once and dove very short video.

Navy Range	Video Name	Date (day mo yr)	Start Time (hr:min:sec)	End Time (hr:min:sec)	Total Video (hr:min:sec)	Daily Sighting ID#	Species	Group Size (best estim.)	Beaufort sea state	Taken by?	Video Utility/ Quality[a]	General Description of Video Content
SOCAL	SOCAL_2011May_13_HDR_ Video_144526-144718_ID7_Fin	5/13/2011	14:45:26	14:47:18	0:01:52	7	Fin whale	1	2	Mari Smultea	poor	Heading 270, whale only seen once for a short period
SOCAL	SOCAL_2011May_13_HDR_ Video_144820-145113_ID7_Fin	5/13/2011	14:48:20	14:51:13	0:02:53	7	Fin whale	1	2	Mari Smultea	fair	Whale seen subsurface, multiple blows
SOCAL	SOCAL_2011May_13_HDR_ Video_165538-165920_ID11_Fin	5/13/2011	16:55:38	16:59:20	0:03:42	11	Fin whale	1	3	Mari Smultea	fair	Heading 360, seen subsurface, multiple blows, possible defecation seen, possible feeding
SOCAL	SOCAL_2011May_14_HDR_ Video_104320-111922_ID6-8_Sperm/Risso's/NRWD	5/14/2011	10:43:20	11:19:22	0:36:02	6, 7, 8	Sperm whale/ Risso's dolphin /NRWD	20/11/50	2	Mari Smultea	excellent	Sperm whales seen with Risso's dolphin heading 360, all sperm whales seen at distance, 4 sperm calves seen, 16 adults. Risso's seen swimming at mouth of one sperm whale. Risso's seen breaching in from of sperm whale, harassing it.

Navy Range	Video Name	Date (day mo yr)	Start Time (hr:min:sec)	End Time (hr:min:sec)	Total Video (hr:min:sec)	Daily Sighting ID#	Species	Group Size (best estim.)	Beaufort sea state	Taken by?	Video Utility/ Quality[a]	General Description of Video Content
SOCAL	SOCAL_2011May_14_HDR_ Video_112229-114239_ID6-8_Risso's/Sperm/NRWD	5/14/2011	11:22:29	11:42:39	0:20:10	6, 7, 8	Risso's dolphin /Sperm whales/ NRWD	20/11/50	2	Mari Smultea	excellent	Breach by Risso's dolphin, surface-active travel, heading 060. Northern right whale dolphins seen porpoising and close to Risso's. Risso's harassing sperm whales.
SOCAL	SOCAL_2011May_14_HDR_ Video_134233-134553_ID16_Blue	5/14/2011	13:42:33	13:45:53	0:03:20	16	Blue whale	2	3	Mari Smultea	Good	Blue whale seen tail popping and a bubble blast, multiple blows
SOCAL	SOCAL_2011May_14_HDR_ Video_135137-135411_ID16_Blue	5/14/2011	13:51:37	13:54:11	0:02:34	16	Blue whale	2	3	Mari Smultea	Good	Blue whale seen traveling at surface, multiple blows
SOCAL	SOCAL_2011May_14_HDR_ Video_140955-141310_ID16_Blue	5/14/2011	14:09:55	14:13:10	0:03:15	16	Blue whale	2	3	Mari Smultea	fair	Whale seen traveling at surface, multiple blows.
SOCAL	SOCAL_2011May_14_HDR_ Video_141954-142344_ID16_Blue	5/14/2011	14:19:54	14:23:44	0:03:50	16	Blue whale	2	3	Mari Smultea	fair	Boat seen traveling towards whale, whale traveling at surface and then dove as boat approached.
			Total Hours:		**5:05:11**							

Table 15. List of Photographs Taken during September 2010 and February – May 2011 Navy SOCAL Aerial Surveys off San Diego, California

Date	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
23-28 September 2011 Photos								
23-Sep	1	Long-Beaked Common Dolphin	25	1	34	34	15:14	15:16
23-Sep	2	Common dolphin sp.	6	37	63	27	15:32	15:33
23-Sep	3	Bottlenose Dolphin	1	67	111	45	15:55	15:57
23-Sep	4	Short-Beaked Common Dolphin	15	114	144	31	16:09	16:10
23-Sep	6	Long-Beaked Common Dolphin	60	147	211	65	16:17	16:19
24-Sep	7	Short-Beaked Common Dolphin	700	1796	1811	16	12:30	12:32
24-Sep	23	California Sea Lion	5	1812	1818	7	12:56	12:57
24-Sep	46	Bryde's whale	1	1819	1829	5	13:44	13:44
24-Sep	55	Long-Beaked Common Dolphin	250	1832	1845	12	14:18	14:21
24-Sep	56	Unidentified Dolphin	1	1849	1856	5	14:24	14:28
24-Sep	69-72	Long-Beaked Common Dolphin	530	1857	1872	12	16:17	16:59
24-Sep	73	Common dolphin sp.	40	1871	1882	11	16:59	17:05
24-Sep	75	Common dolphin sp.	300	1884	1889	6	17:10	17:13
24-Sep	77	Long-Beaked Common Dolphin	9	1890	1895	6	17:16	17:16
25-Sep	7	Common dolphin sp.	1100	1917	1920	4	11:08	11:12
25-Sep	8	Common dolphin sp.	400	54	60	6	11:09	11:11
25-Sep	11	Short-Beaked Common Dolphin	100	1921	1929	9	11:41	11:43
25-Sep	11	Short-Beaked Common Dolphin	100	61	64	4	11:41	11:43
25-Sep	12	Common dolphin sp.	400	1930	1932	3	11:48	11:49
25-Sep	13	Northern elephant seal	11	65	72	8	11:56	11:58
25-Sep	15	California sea lion	35	1938	1943	6	12:18	12:20

Date	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
23-28 September 2011 Photos (continued)								
25-Sep	18	Common dolphin sp.	1600	78	87	10	12:43	12:44
25-Sep	19	Common dolphin sp.	150	89	92	4	12:53	12:53
25-Sep	19	Common dolphin sp.	150	1944	1955	12	12:54	12:58
25-Sep	21	Common Dolphin sp.	50	1956	1966	11	13:03	13:06
25-Sep	23	Short-Beaked Common Dolphin	75	1968	1972	5	13:23	13:25
25-Sep	24	Common dolphin sp.	200	94	98	5	13:24	13:24
26-Sep	15	Common dolphin sp.	1000	1987	2015	29	13:14	13:40
26-Sep	28	Short-Beaked Common Dolphin	450	2021	2038	18	16:03	16:10
27-Sep	16	Risso's dolphin	5	1	6	6	10:50	11:56
27-Sep	29	Minke whale	1	7	19	13	11:56	11:57
27-Sep	58	Common dolphin sp.	275	28	34	7	14:58	15:00
27-Sep	64	Common dolphin sp.	1299	36	46	11	15:29	15:30
28-Sep	3	Common dolphin sp.	600	11	66	56	9:25	9:29
28-Sep	5	Sei/Bryde's whale	3	68	126	59	9:56	9:58
28-Sep	12	Common dolphin sp.	400	130	210	71	13:10	13:12
28-Sep	23	Bottlenose dolphin	18	215	246	31	14:23	14:30
14-Feb	3	Bottlenose dolphin	6	778	780	3	13:52	13:52
14-19 February 2011 Photos								
14-Feb	5	Common dolphin sp.	75	798	813	16	14:21	14:24
15-Feb	1	Gray whale	2	838	882	45	8:47	9:14
15-Feb	3	Short-Beaked Common Dolphin	25	884	889	16	9:37	9:38
15-Feb	4	Short-Beaked Common Dolphin	20	901	906	6	10:01	10:01

Date	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
14-19 February 2011 Photos (continued)								
15-Feb	5	Risso's dolphin	6	908	937	30	10:07	10:47
15-Feb	6	Risso's dolphin	100	938	976	39	10:51	11:07
15-Feb	12	Short-Beaked Common Dolphin	500	978	992	15	13:25	13:27
15-Feb	13	Gray whale	1	994	1003	10	13:43	13:43
15-Feb	14	Fin whale	1	1005	1007	3	14:02	14:02
15-Feb	15	Risso's dolphin	8	1009	1034	26	14:08	14:09
15-Feb	17	Fin whale	2	1035	1052	18	14:35	14:37
15-Feb	19	Short-Beaked Common Dolphin	500	1055	1068	14	15:01	15:06
15-Feb	20	Gray whale	1	1070	1079	10	15:10	15:10
15-Feb	21	Short-Beaked Common Dolphin	900	1081	1107	27	15:18	15:20
15-Feb	22	Long-Beaked Common Dolphin	22	1109	1155	47	15:37	15:48
14-19 February 2011 Photos								
17-Feb	10	Long-Beaked Common Dolphin	700	1161	1166	6	9:54	9:55
17-Feb	14	Short-Beaked Common Dolphin	10	1168	1172	5	10:28	10:30
17-Feb	15	Short-Beaked Common Dolphin	10	1174	1178	5	10:34	10:34
17-Feb	32	Short-Beaked Common Dolphin	1800	1181	1225	45	14:16	14:19
17-Feb	34	Bottlenose dolphin	2	1227	1233	7	14:39	14:40
17-Feb	38	Gray whale	1	1235	1315	79	14:54	15:17
30 March - 1 April 2011 Photos								
30-Mar	4	Short-Beaked Common Dolphin	40	1373	1382	10	19:10	19:12
30-Mar	5	Common dolphin sp.	18	1383	1386	4	19:26	19:26
31-Mar	4	Risso's dolphin	18	1415	1468	33	11:06	11:18

Date	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
30 March - 1 April 2011 Photos (continued)								
31-Mar	5	Minke whale	1	1426	1455	20	11:08	11:11
31-Mar	7	Minke whale	2	1470	1512	44	11:43	11:47
31-Mar	9	Long-beaked common dolphin	35	1513	1527	15	12:13	12:15
31-Mar	11	Long-beaked common dolphin	300	6	48	42	16:08	16:10
31-Mar	12	Common dolphin sp.	225	50	62	13	16:21	16:23
31-Mar	13	Gray whale	5	63	82	20	16:26	16:28
31-Mar	17	Risso's dolphin	12	101	123	22	16:52	16:53
31-Mar	18	Risso's dolphin	20	124	244	120	17:14	17:18
1-Apr	23	Risso's dolphin	20	12	29	17	9:20	9:20
1-Apr	24	Northern right whale dolphin	8	30	117	81	9:20	9:33
12-20 April 2011 Photos								
12-Apr	1	Common dolphin sp.	440	1	17	12	11:46	12:10
12-Apr	4	Risso's dolphin	25	24	32	8	12:38	12:40
12-Apr	10	Common dolphin sp.	15	34	38	5	14:43	14:45
13-Apr	6	Bottlenose dolphin	55	39	48	9	12:25	12:26
14-Apr	7	Fin whale	1	52	72	21	10:24	10:52
14-Apr	14	Common dolphin sp.	700	73	81	8	13:29	13:29
15-Apr	1	Bottlenose dolphin	25	82	85	4	8:47	8:47
15-Apr	5	Common dolphin sp.	1100	87	93	6	10:36	10:36
15-Apr	6	Humpback whale	1	95	105	11	11:11	11:11
15-Apr	12	Short-Beaked Common Dolphin	1200	107	119	12	12:40	12:42
15-Apr	4	Short-Beaked Common Dolphin	1100	123	133	10	15:30	15:33

Date	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
12-20 April 2011 Photos (continued)								
16-Apr	11	Common dolphin sp.	200	138	148	10	14:48	14:49
16-Apr	14	Long-Beaked Common Dolphin	300	150	160	10	16:10	16:12
18-Apr	5	Risso's dolphin	12	163	170	8	13:54	13:59
18-Apr	7	Bottlenose Dolphin	4	172	177	5	15:19	15:23
18-Apr	13	Common dolphin sp.	50	178	180	3	14:19	14:19
18-Apr	14	Common dolphin sp.	145	182	183	2	14:28	14:28
18-Apr	15	Bottlenose dolphin	32	185	193	8	16:58	16:48
18-Apr	16	Long-Beaked Common Dolphin	175	195	196	2	17:21	17:21
18-Apr	19	Common dolphin sp.	105	198	204	5	17:44	17:47
19-Apr	1	Common dolphin sp.	105	205	223	18	10:31	10:32
19-Apr	3	Common dolphin sp.	120	224	248	24	11:28	11:29
19-Apr	5	Long-Beaked Common Dolphin	350	250	273	23	11:36	11:44
19-Apr	8	Common dolphin sp.	225	276	287	11	12:35	12:35
19-Apr	4	Common dolphin sp.	100	281	301	20	16:43	16:44
19-Apr	5	Short-Beaked Common Dolphin	1750	302	323	21	17:11	17:13
20-Apr	1	Long-Beaked Common Dolphin	445	325	342	17	10:21	10:23
20-Apr	7	Blue whale	1	343	364	21	11:31	11:42
20-Apr	11	Long-Beaked Common Dolphin	800	366	393	27	14:23	14:44
20-Apr	12	Long-Beaked Common Dolphin	200	395	469	74	15:33	15:38
9-14 May 2011 Photos								
9-May	1	Long-Beaked Common Dolphin	50	470	491	21	15:33:00	15:43:00
10-May	4	Fin whale	1	501	630	129	10:15:00	10:38:00

Date	Daily Sighting ID No.	Species Common Name	Best Group Size Estim.	Start Frame #	End Frame #	Total Photos	First Frame Time	Last Frame Time
9-14 May 2011 Photos (continued)								
10-May	3	Harbor seal	1	631	636	5	10:40:00	10:40:00
10-May	10	Short-Beaked Common Dolphin	140	638	651	13	11:34:00	11:35:00
10-May	11	Short-Beaked Common Dolphin	625	652	677	25	11:35:00	11:42:00
10-May	12	Humpback whale (dead)	1	680	709	29	12:07:00	12:10:00
10-May	20	Fin whale	1	711	719	8	16:40:00	16:40:00
10-May	23	Blue whale	1	722	734	12	16:43:00	16:44:00
10-May	24	Blue whale	1	737	756	19	16:46:00	16:47:00
11-May	1	Humpback whale (dead; same animal as above)	1	795	855	60	16:01:00	16:04:00
12-May	6	Short-Beaked Common Dolphin	350	858	889	31	11:16:00	11:20:00
12-May	9	Common dolphin sp.	125	892	899	7	13:50:00	13:50:00
12-May	11	Fin whale	1	913	936	23	16:09:00	16:09:00
12-May	1	Fin whale	1	939	1135	196	16:25:00	16:43:00
13-May	2	Common dolphin sp.	175	1136	1170	34	13:37:00	13:39:00
13-May	4	Common dolphin sp.	300	1173	1175	2	13:49:00	13:49:00
13-May	11	Fin whale	1	1178	1212	34	16:41:00	16:44:00
14-May	4	California sea lion	4	1215	1270	55	10:15:00	10:16:00
14-May	5	Bottlenose dolphin	40	1273	1299	26	10:23:00	10:24:00
14-May	6	Sperm whale	20	1301	1469	168	10:37:00	10:47:00
14-May	9	California sea lion	1	1472	1494	22	11:52:00	11:57:00

Table 16. List of all focal behavioral follows longer than 10 minutes duration conducted during the May SOCAL 2011 aerial monitoring surveys off San Diego, California (no focals were videotaped for <10 min). Video was taken on some of these groups as indicated in Appendix C and within the table.

Date	Start Time	End Time	Duration of Focal (hr:min)	Latitude	Longitude	Species	Group Size	Notes
9-May	15:46	17:01	1:14	33.243000	-117.534667	Blue whale	1	First sighting was a few blows as it traveled north then dove. No video or behaviors recorded until after the 2 fins below were followed.
9-May	15:48	16:21	0:33	33.251500	-117.543167	Fin whale	2	Seen while circling looking for blue whale; did one surfacing sequence on video then did rest of video session on blue whale above. Definite dark bodies and white right jaw seen.
10-May	9:42	11:10	1:28	32.791000	-117.385677	Blue whale	2	Initial focal group was 2 blues that then disaffiliated not long after. We continued following one of these blue whales then followed bottlenose dolphins then presumably the same blue again then Risso's for 15 min then left the approx. 1-mile radius area.
10-May	9:56	10:47	0:51	32.778667	-117.400500	Fin whale	1	Seen while circling and doing focals on blue whale.
10-May	10:59	11:10	0:11	32.813	-117.35833	Risso's dolphin	16	Socializing, seen while circling blue whale group. First half of video blue whale, then focuses on Risso's dolphin behavior.
10-May	15:57	16:08	0:11	32.87733	-117.31383	Blue whale	2	Feeding, no reaction observed even when we flew close to them (approx 300 m distance).
11-May	13:58	14:24	0:26	32.66250	-117.58583	Risso's dolphin	32	20 Risso's line abreast initially seen on transect just before turning for bottlenose dolphins. Bottlenose dolphins interspersed with the Risso's. Video taken during this focal

Date	Start Time	End Time	Duration of Focal (hr:min)	Latitude	Longitude	Species	Group Size	Notes
11-May	13:59	14:22	0:23	32.67300	-117.57500	Common bottlenose dolphin	8	Interspersed with the Risso's group above, video taken during this focal.
11-May	15:05	15:25	0:20	32.80117	-117.98383	Risso's dolphin	7	Dolphins appeared to be staying below water surface longer than usual. Video taken during this focal.
11-May	15:27	15:43	0:16	32.79800	-118.01133	Risso's dolphin	4	Traveling fast fanning out then slowed down. Video taken during this focal.
12-May	16:03	16:43	0:40	32.60067	-117.56500	Fin whale	1	Video and photos taken during this focal of a fin whale with unusually white pectoral fins.
12-May	16:54	17:23	0:29	32.51917	-117.59150	Risso's dolphin	14	Video taken during this focal. Surface-active behaviors, moving all different directions, breaching (Navy vessel in area and seen in video).
13-May	13:57	14:28	0:31	32.62350	-117.52467	Fin whale	2	Video taken during this focal. 2 fin whales traveling subsurface, lined up 10 body lengths apart.
13-May	14:40	14:51	0:11	32.70267	-117.61617	Fin whale	1	Video taken during this focal. One animal seen subsurface. Another fin whale was approximately 1 km (0.5 nm) away from this focal fin whale.
13-May	16:40	16:59	0:19	32.99517	-117.58300	Fin whale	1	Video taken during this focal. Whale seen subsurface, multiple blows, defecating; animal believed to be feeding.

Date	Start Time	End Time	Duration of Focal (hr:min)	Latitude	Longitude	Species	Group Size	Notes
14-May	10:36	11:43	1:07	32.61700	-117.72617	Sperm whale	20	Video and photos taken during this focal of 4 sperm whale calves seen &16 adults (no bulls seen). One adult initially followed then the other 19 sperm whales surfaced in tight association. Sperm whales eventually spread out then dove within ~1 min of each other. Associated with northern right whale dolphins and Risso's dolphins. Risso's seen swimming at/"rushing" heads of sperm whales; sperm whales appeared to react to Risso's approaches to head by dropping their lower jaw. Risso's seen breaching in from of sperm whale, harassing it.
14-May	10:41	11:43	1:02	32.62283	-117.72467	Risso's dolphin	11	Video and photos taken during this focal. Breach by Risso's dolphin, surface-active travel. Northern right whale dolphins seen porpoising and close to Risso's. Risso's appeared to be harassing sperm whales (see sperm whales above).
14-May	10:41	11:43	1:02	32.62283	-117.72467	Northern right whale dolphin	50	Video and photos taken during this focal. Interspersed with the sperm whale nursery group above. Porpoising in front of sperm whale group.
14-May	13:32	14:21	0:49	32.76567	-117.38950	Blue whale	2	Video taken during this focal. Blue whale seen "tail cocking" and bubble blasting multiple times. This behavior rarely seen previously.
		Total:	**12:03**					

Number of 5-10 min focals for May = 0
Number of >10 min focals for May = 18

APPENDIX B: ABSTRACTS SUBMITTED TO THE 19TH BIENNIAL CONFERENCE ON THE BIOLOGY OF MARINE MAMMALS 2011

Interactions between Sperm Whales and Risso's and Northern Right Whale Dolphins off San Diego

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Aerial surveys provide a valuable platform to record and document behavior of marine mammals above and below the sea surface. This approach is advantageous in avoiding disturbance from the observational platform while circling outside the sound cone of the plane. Since 2008, the U.S. Navy has instituted a marine mammal monitoring program in southern California from several platforms, including aerial surveys, and previously undocumented behaviors and species interactions have been recorded during the aerial effort. This included focal behavioral interactions between sperm whales, northern right whale dolphins, and Risso's dolphins on 14 May 2011, 24 nm west of San Diego, CA. This ~1.5 hr encounter was documented in detail with high-definition digital photographs and video as the group traveled NE along the edge of a steep underwater drop-off. Risso's dolphins initiated charges towards the heads of the sperm whales on multiple occasions, followed by fast retreats. Sperm whale adults responded by displaying an open lower jaw. Risso's dolphins appeared to direct this behavior only toward adult sperm whales that had recently surfaced from long (> 20 min) dives; it was not directed toward the four calves in the group. Northern right whale dolphins intermingled with the Risso's dolphins and sperm whales, although they did not approach sperm whales as closely or abruptly as the Risso's dolphins. While similar apparently aggressive Risso's dolphin behavior has been documented toward other cetacean species, this is the first known occurrence of head-on charging by Risso's dolphins, accompanied by the elicited jaw display response from sperm whales. The interaction may be similar to pilot whales being aggressive towards sperm whales, and may function in acquiring regurgitated sperm whale food, or other needs by the Risso's dolphins.

Comparison of Blue and Fin Whale Behavior, Headings and Group Characteristics in the Southern California Bight during Summer and Fall 2008-2010

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Baseline undisturbed behavior and social patterns of blue (*Balaenoptera musculus)* and fin whales (*B. physalus*) are not well described and are needed to identify and understand potential effects of anthropogenic activities. Behavioral data for blue and fin whales were collected during line-transect and focal-follow effort. Initially observed behavior state, heading, and minimum and maximum inter-individual dispersal distance were recorded during line-transect sampling. Focal

groups were circled for 10-60+ minutes and videotaped from outside Snell's sound cone to avoid disturbance. During 24,736 km of survey effort, 51 fin whale sightings (85 individuals) and 49 blue whale sightings (81 individuals) were seen. Over 7 hours of video was collected for 16 blue and 15 fin focal follows. During the summer seasons, blues (n=48) were seen more commonly than fins (n=35); in fall, fins (n=16) were seen significantly more frequently than blues (n=1). Mean group size was 1.7 whales for both species. Initially observed blue behavior was usually travel (85%) or mill (11%). Observed fin whale behavior was also mostly travel (90%), mill (4%), or surface-active travel (4%). Both species were seen socializing in fall but not summer; foraging was observed in summer through fall. Mean initial dispersal for blues and fins was 9.1 and 14.2 body lengths, respectively. In summer, blues were most frequently (26%) seen headed S; in fall (n=2), they were headed only inshore (E). In summer, fin whales were most commonly headed SSW (26%) or WNW (26%); in fall, they were headed mostly NE (38%) or WSW (38%). Dive/respiration/behavioral event rates were also collected. Both species may directly compete for food based on observations of inter-specific maneuvering for a bait ball. Data represent the most extensive record of systematic undisturbed behavior on these species in SOCAL and include social interactions not previously documented in this region.

Got Milk? Aircraft Observations Provide Rare Glimpses into Whale Calf Nursing and Back Riding.

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Nursing behavior by large cetaceans in situ is not well described. During ~30,000 km of aerial surveys off Southern California to monitor marine mammals relative to U.S. Navy military training activities (2008-2011), nursing behaviors were documented for three species: Eastern Pacific gray whale (*Eschrichtius robustus*), fin whale (*Balaenoptera physalus*) and killer whale (*Orcinus orca*). Photographs, video, notes and audio recordings were used to analyze mother-calf interactions. Back riding occurred in gray and fin whales, as described for bowhead whale (*Balaena mysticetus*) mother-calf pairs by Würsig et al. (1999). During slow sub-surface travel, a fin whale calf swam alongside mother's peduncle area, touching her head-first for short (<1 min) bouts at a 45° angle. During the sighting (~50 min) the calf switched from one side of the mother's peduncle to the other 12 times, usually by "riding" (n=8) the mother's back or swimming underneath her (n=4). Nursing was assumed based on the persistent (~1 min) position of the calf's head relative to mother's peduncle/teat area. Observations of the gray whale pair showed similar behavior (~19 min) with calf riding mothers back 3 times, except mother was resting not traveling. During nursing, the calf faced mother at a 45° angle while mother held up her flukes. Two apparent nursing positions of a traveling killer whale mother-calf pair were also photo-documented (~40 min). One position showed both whales lying parallel, facing one another, in the same orientation. The second position showed the same mother lying on her back, with calf nursing on top of mother, ventral side to ventral side. These positions were similar to those

described among captive killer whales. Observations indicate nursing occurs during travel and calves of other whale species back ride. Data contribute to rare documentations of whales nursing in the wild, furthering the understanding of cetacean mother-calf interactions.

Changes in Abundance, Density and Diversity of Marine Mammals in the Southern California Bight 1998-1999 vs. 2008-2011

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Twelve line-transect aerial surveys occurred during fall/summer 2008-2011 to monitor the occurrence, abundance and behavior of marine mammals in the Southern California Bight. The study area overlapped where Carretta et al. (2000) flew surveys in 1998-1999, coinciding with their "warm-water period". Density and abundance were estimated using standard line transect methods and DISTANCE software. Analyses were limited to 12,206 km flown in Beaufort 0-4 conditions and 495 marine mammal sightings of the seven most commonly observed species. Blue whale densities were all well below historical estimates. Fin whales continue to be the most commonly abundant large whale. Risso's dolphins have apparently dramatically increased in numbers and/or distribution over the last several decades: calculated density east of San Clemente Island (SCI) was 19.99 animals/100 km². This is much higher than those for Carretta et al.'s warm season, but similar to those they estimated for the cold season. Our densities of common dolphins were lower than Carretta et al.'s warm-water season (318.99 animals/100 km² east of and 58.43 animals/100 km² west of SCI). However, short-beaked common dolphins were still by far the most abundant species (~29,044 individuals). Historically, Pacific white-sided dolphins were seen only in the cold-water season, but we had 26 sightings (density 19.7 individuals/100 km²) in the warm-water period. Pilot whales, though historically common, were never seen. Results indicate that recent patterns of cetacean relative abundance and presence are, in many cases, very different from historical records. This is likely related to previous exploitation and depletion of these species and long-term changes in oceanographic conditions, concomitant changes in prey distribution and densities, and anomalous El Niño and La Niña events. This study provides the only available recent estimates of abundance for marine mammal species east and west of San Clemente Island where the U.S. Navy conducts major training exercises.

Rare Sightings of Bryde's Whales (*Balaenoptera brydei/edeni*) in the Southern California Bight

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Bryde's whales (*Balaenoptera brydei/edeni*) have been considered an anomalous occurrence in the Southern California Bight (SCB). Thus, they typically have been excluded from species lists associated with SCB management documents. In the last 40 years only two visual sightings of

Bryde's whales were documented in California waters, the last one in 1991 (Carretta et al. 2008). This is despite extensive systematic vessel and aerial surveys and presumed recent recordings of Bryde's whale vocalizations in the SCB. Bryde's whales are notoriously difficult to differentiate in the field, both from each other and also from fin (*B. physalus*) and sei whales (*B. borealis*), given the subtle differences in physical characteristics. Between August 2006 and September 2010, we photo-documented five sightings of five single Bryde's whales in the SCB. Two of the five sightings occurred in October 2008 and September 2010 during 33,880 km of aerial surveys. The remaining three sightings occurred during small-vessel surveys that included offshore waters: two in June 2006 and one in September 2010. These sightings combined with other reports of presumed vocalizations suggest that Bryde's whale numbers may be increasing in the SCB. This may be related to global warming, large-scale oceanographic events (e.g., El Nino and La Nina) and resulting changes in prey availability. Recent sightings reported herein indicate that the Bryde's whale should be considered as a species present in the SCB and photo-documentation is critical to ascertain species.

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Bryde's Whale (*Balaenoptera brydei/edeni*) Sightings in the Southern California Bight[1]

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Keywords: Bryde's whale, *Balaenoptera brydei/edeni,* Southern California Bight, Eastern Tropical Pacific, El Niño, La Niña, ENSO, distribution

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ABSTRACT

The typically tropical Bryde's whale (*Balaenoptera brydei/edeni*) has been considered an extralimital occurrence in the Southern California Bight (SCB); thus, it has frequently been excluded from species lists associated with SCB management documents. In the past 40 years, only two visual sightings of Bryde's whales were documented in California waters, most recently in 1991. This is despite extensive systematic vessel and aerial surveys, and recent presumed recordings of Bryde's whale calls in the SCB. Bryde's whales are notoriously difficult to differentiate in the field from fin (*B. physalus*) and sei whales (*B. borealis*) given the subtle differences in physical characteristics. Between August 2006 and September 2010, we photo-documented five sightings of single Bryde's whales in the SCB. Two of the five sightings occurred in October 2008 and September 2010 during 33,880 km of Navy-funded aerial survey monitoring of marine mammals. The remaining three sightings occurred during small-vessel surveys that included offshore SCB waters: two in June 2006 and one in September 2010. These sightings, combined with recently recorded Bryde's calls, suggest that Bryde's whale numbers may be increasing in the SCB. These may be related to climate change, large-scale oceanographic events (e.g., El Niño Southern Oscillation (ENSO) events) and resulting changes in prey distribution and availability. We suggest that the Bryde's whale should be considered as a species normally present

in the SCB and that photo-documentation or genetic sampling is critical to confirm species for stock management purposes.

Introduction

Given the paucity of confirmed sightings over the last 20 years, and its traditional, more southern warm-water distribution, the Bryde's whale (*Balaenoptera brydei/edeni*) has been excluded from many comprehensive reviews of cetaceans occurring in the Southern California Bight (SCB) (Carretta et al. 2011). The last United States Pacific marine mammal stock assessment to include the Bryde's whale was in 2006 (Carretta et al. 2007). During the past nearly five decades only two confirmed published visual sightings of Bryde's whales were documented off southern California (**Table 1**). In January 1963, a Bryde's whale (originally misidentified as a fin whale) was seen near La Jolla, California (Nicklin 1963, Morejohn and Rice 1973) (**Table 1**). In October 1991, another was sighted off Monterey Bay (Barlow 1997). The latter sighting along with five other possible sightings (labeled as sei (*B. borealis*) or Bryde's whales) occurred during extensive systematic vessel and aerial surveys conducted in California waters between 1991 and 2008 by the Southwest Fisheries Science Center of the National Marine Fisheries Service (e.g., Carretta and Forney 1993, Hamilton et al. 2009, Barlow et al. 2010) (**Table 1**).

The natural history of the Bryde's whale is not well known (Kato and Perrin 2009), though it is the most common rorqual species in the eastern tropical Pacific (ETP) and the Gulf of California (located approximately 350 km south of San Diego) (e.g., Tershy et al. 1990, Tershy 1992, Jackson et al. 2008, Barlow et al. 2009). Breeding and calving occur year-round, and short seasonal migrations take place in some areas (Jefferson et al. 2008). However, longer movements of Bryde's whales from the tropical Pacific (25°N) to the east coast of Japan (43°N) have also been documented by Japanese tagging in the western Pacific in the late 1980s (Kishiro 1996).

Bryde's whales in California are believed to belong to the ETP stock for which there is no current population trend data and no biological basis for stock separation (Carretta et al. 2007). The last estimated abundance of Bryde's whales in California, Oregon, and Washington coastal waters in 2006 was 12 individuals (CV=2.0) (Barlow 1997, Carretta et al. 2007). Bryde's whales are not listed as a Threatened or Endangered species under the ESA and are not considered a strategic stock under the MMPA (Carretta et al. 2007, Jefferson et al. 2008). Kanda et al. 2007 suggested low genetic variability occurs between various sub-populations of Bryde's whales in the western North Pacific, South Pacific, and Indian oceans, and that these sub-populations may need separate management actions. It is unknown if the ETP stock of Bryde's whale is also genetically isolated.

Recent passive acoustic monitoring data from 2000-2009 suggest that Bryde's whale occurrence in the SCB has been increasing since 2003, with peak call rates recorded between August and October (Kerosky et al. in prep.). However, no Bryde's whale sightings have been matched to these calls. Bryde's whales are notoriously difficult to differentiate in the field from sei and fin whales (*B. physalus*) given the subtle differences in physical characteristics including body shape and coloration (Jefferson et al. 2008, Smultea et al. 2010). A clear close-up view of the unique presence of three prominent rostrum ridges, combined with dorsal fin shape, is typically required to confirm a Bryde's whale at sea (Omura 1966, Jefferson et al. 2008). All other balaeonopterids have only one prominent central rostrum ridge, although fin and sei whales sometimes have much-reduced auxiliary rostrum ridges (T. Jefferson pers. observ. 2011). Consequently, many historical sightings typically have not distinguished between Bryde's and sei whales and sometimes fin whales when the latter's distinctive right white jaw cannot be seen (Jefferson et al. 2008).

Between August 2006 and September 2010, we photo-documented five separate single Bryde's whales in SCB waters. Details of our five and the two Bryde's whale sightings documented over 20 years prior are summarized in **Table 1**. Sightings occurred over bottom depths ranging up to 5,000 m and approximately 75 to 120 km from the mainland southern California coast (four of the five sightings were 35 to 70 km west of San Clemente Island) (**Figure 1**). One sighting occurred in October 2008 and another in September 2010 during 33,880 km of aerial surveys conducted from a fixed-wing Partenavia P68-C or P68-OBS aircraft (Smultea et al. 2009, 2011). The remaining three sightings occurred during extensive small-vessel surveys that included offshore waters west of San Clemente Island: two in June 2006 and one in September 2010. Photographs were taken with a Canon 20D digital camera and a Canon 100-400 mm zoom lens or a 70-200 2.8 zoom lens with a 1.4x converter. Sample photographs of our sightings are provided in **Figures 2-4**. All of our sightings required close examination of the photographs to confirm species identification and were reviewed by at least three species experts.

Recent Bryde's whale calls and sightings in southern California waters may represent a range expansion related to increasing periods or areas of warmer water temperatures including the summer/fall, El Niño Southern Oscillation (ENSO) events; the offshore poleward-flowing Davidson Current period from late fall to late winter (November to January) inshore of the California Current; and climate change (Kerosky et al., in prep.). Southern California occasionally experiences seasonal El Niño oceanographic events that typically increase water temperatures based on a threshold of 0.5 degrees Celsius for the Oceanic Niño Index (ONI) from fall through winter (NOAA 2011). Since 1990, warmer El Niño water temperatures have occurred in Southern California during 14 of the past 21 years (NOAA 2011). Most recently, El Niño started in September 2006 and lasted until early 2007 (NOAA 2011). From June 2007, a moderate La Niña (cool-water) event strengthened through early 2008 but weakened by summer 2008 (NOAA 2011). The 2007–2008 La Niña event was the strongest since the 1988–1989 event. El Niño conditions started again in June 2009, peaked in January–February 2010, and persisted until May 2010 (NOAA 2011). Since then, sea surface temperature (SST) anomalies have been negative (i.e., colder La Niña) (NOAA 2011).

Of the seven Bryde's whale sightings known from southern California, five were seen during winter or fall with the remaining two seen during summer (August) (**Table 1**). Three of these were seen during warm-water El Niños in 1991 and 2006, three were seen during cool-water La Niñas in 1963 and 2010, and one was seen during a non-El Niño/La Niña period (fall 2008). Five of the seven sightings occurred in offshore waters west of San Clemente Island (**Figure 1**). Although our sightings do not appear to be directly correlated with ENSO events, recent increased sightings and calls in the SCB may be indirectly related through effects on prey distribution.

Data reported herein indicate that Bryde's whales occur off southern California more often than previously believed. This may be a fairly recent phenomenon related to warming of ocean temperatures associated with oceanographic events such as ENSO and climate change that influence the availability and distribution of prey (Learmonth et al. 2006, Kerosky et al. in prep.). Salvadeo et al. (2011) determined that inter-annual variability of Bryde's whale occurrence in the southwestern Gulf of California was highly correlated with the ENSO and its likely impact on prey availability. Our sightings combined with presumed recordings of Bryde's whale calls suggest that this species' use of the SCB is increasing, possibly in response to increasing water temperatures and other oceanographic changes affecting prey distribution. Our limited sightings point to offshore use of the SCB, consistent with Kerosky et al.'s (in prep.) suggestion that SCB Bryde's whales may initially travel north offshore then return south closer to shore. It is our hope that the reporting of our sightings here will lead to: (1) a better understanding of this species' occurrence in the SCB; (2) consistent inclusion of the Bryde's whale in environmental impact analyses and stock assessment reports in southern California; and (3) increased efforts to photo-document and/or genetically sample future sightings to ascertain species.

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Table 1. Documented sighting information for Bryde's whales (Balaenoptera brydei/edeni) off central and southern California including the Southern California Bight 1963-2010.

Date	Time	Sighting Platform	Location	Lat./Long.	Group Size	Approx. Body Length (m)[2]	Total Obs. Time (min)	Species Confirmation Source	Comments	Source
8-Jan-1963	-	vessel	1 km from La Jolla shore, San Diego, CA	32.47/ -118.44	1	13.7	180	still photographs, video	whale entangled in gill net	Nicklin 1963, Morejohn and Rice 1973
5-Oct-1991	-	vessel	Monterey Bay, CA	36.1162/-125.1496	2	13	20	naked eye, photographs	Travel at surface for nearly two minutes blowing 5-6 times before submerging for approx. 6 minutes; evasive at close range abruptly changing course while submerged	J. Barlow pers. comm., NMFS SWFSC
17-Aug-2006	11:04	rigid-hulled inflatable boat (RHIB)	-	32.9/-119.1815	1	Adult	42	digital photographs	Milling, foraging. Some dives 8-9 minutes, surfacing within 300m of descent location	Cascadia, Sighting N No. N1-9
18-Aug-2006	14:29	RHIB	_	32.7515/-118.9345	1	Adult	6	digital photographs	Milling and traveling	Cascadia, Sighting N No. N1-5
19-Oct-2008	12:56	airplane	75 mi NE of SCI	33.1184/-118.3312	1	Adult_	>1	digital photographs	Whale surfaced then dove while the aircraft circled once at an altitude of approx. 250 m whale was traveling, blow was relatively small	Smultea et al. 2009, SES Daily Sighting N No. 6

Date	Time	Sighting Platform	Location	Lat./Long.	Group Size	Approx. Body Length (m)[2]	Total Obs. Time (min)	Species Confirmation Source	Comments	Source
24-Sept-2010	13:56	airplane	_	32.9278/-118.9063	1	_Adult	5	digital photographs	Initially called unidentified baleen whale but then looked at photos and saw 3 rostral ridges; same night T.A. Jefferson confirmed photo as Bryde's whale	Smultea et al. 2011, SES Daily Sighting N No. 5
25-Sept-2010	9:49	RHIB	_	32.8549/-119.0826	1	_	25	digital photographs	Fast travel west	Cascadia, Sighting N No. PHY-1

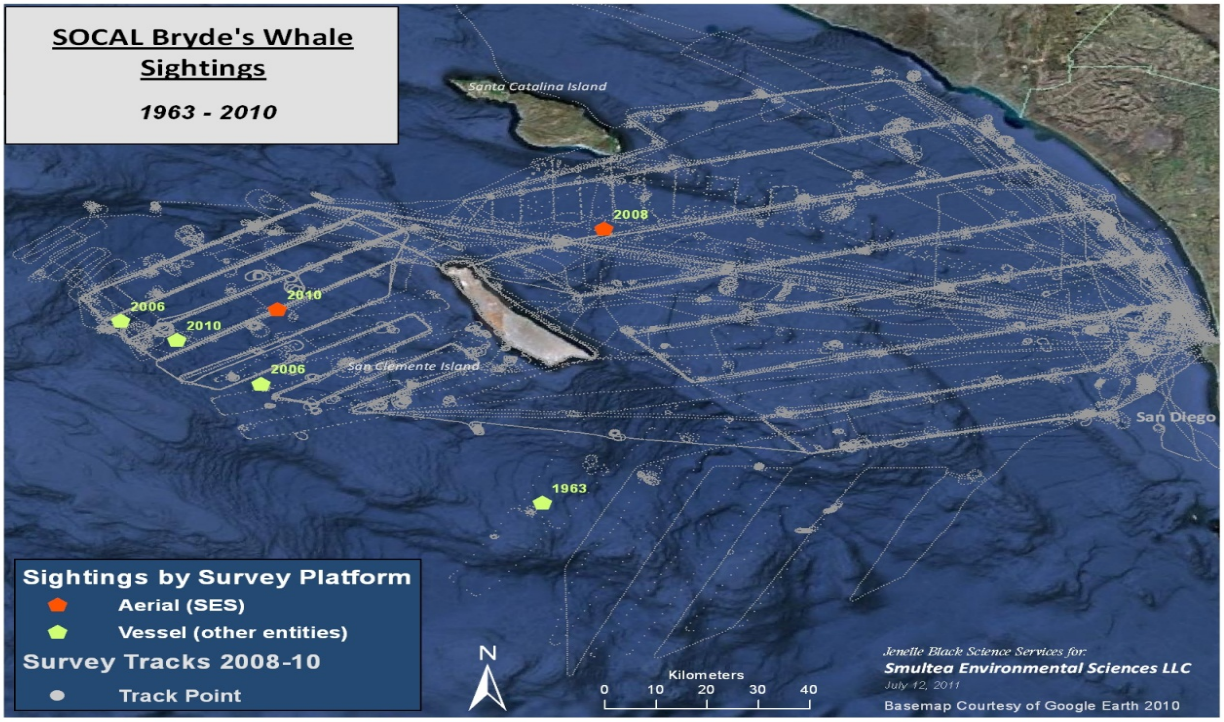

Figure 1. Bryde's whale sighting locations from 1963-2010 in the Southern California Bight. Note: the 1991 central California Bryde's whale sighting is excluded from this map due to distance from the other sightings depicted here.

Figure 2. Bryde's whale seen 24 September 2010. Photographed by Bernd Würsig under NMFS permit 15369.

Figure 3. Bryde's whale seen during 19 October 2008, showing diagnostic characters of the species. Photographed by Lori Mazzuca under NMFS permit 14451.

Figure 4. Bryde's whale seen 17 August 2006. Photographed by Annie Douglas under NMFS permit 540-1811-00.

DENSITY AND ABUNDANCE OF MARINE MAMMALS AROUND SAN CLEMENTE ISLAND, SAN DIEGO COUNTY, CALIFORNIA, IN 2008-2010

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Note: This paper is in draft form and does not include the cool-water surveys conducted in winter 2011, which will be added in the near future. Please do not cite without permission.

Abstract

In order to provide the US Navy with up-to-date estimates of density and abundance of marine mammals in waters off the San Diego coastline used extensively for training and other exercises, we conducted a set of eight aerial surveys of the waters around San Clemente Island between October 2008 and September 2010. The platform used was a *Partenavia* P68-C or P68-OBS (glass-nosed) high-wing airplane. Estimates of abundance were made using line transect methods and the software DISTANCE 6.0. We sighted 18 species of marine mammals during the surveys. Due to limited sample sizes for some species, we pooled species with similar sighting characteristics and made four estimates of the probability density function for baleen whales, large delphinids, small dolphins, and California sea lions. Estimates of density and abundance were calculated for species observed more than five times on effort. We estimated that during the warm-water (May-October) season of the 2008-2010 study period, there were 13 blue whales (*Balaenoptera musculus*), 66 fin whales (*Balaenoptera physalus*), 135 Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), 2,537 Risso's dolphins (*Grampus griseus*), 585 common bottlenose dolphins (*Tursiops truncatus*), 30,034 common dolphins (*Delphinus* spp., mostly *D. delphis*), and 2,534 California sea lions (*Zalophus californianus*) present. Recent surveys should allow the calculation of cold-water (November-April) season estimates in the near future.

Introduction

Southern California is home to perhaps more marine mammal biologists than any similarly sized geographic region in the world. Extensive research has been conducted on marine mammals in the Southern California Bight (SCB), and hundreds of papers have been published on the marine mammals of this region. The pinniped populations of the area, which mostly use the offshore islands for breeding and hauling out, have been extensively monitored for many decades (Lowry et al. 1992, 2008; Stewart et al. 1993). A large-scale set of ship and aerial surveys assessed density and abundance from 1975-1978 in the SCB, but this information is now well over 30 years old and is considerably out-of-date (Dohl et al. 1981, 1986). The California coastal bottlenose dolphin population, which has a large portion of its range in the SCB, has been extensively studied, and ranging patterns (Defran et al. 1999) and abundance/population size have been recently assessed (Carretta et al. 2000; Dudzik et al. 2006). Also recently, passive acoustic monitoring (PAM) studies have begun to supplement knowledge from observational studies. In particular, distribution and habitat patterns of some delphinids species have been studied using these sensors (Soldevilla et al. 2008, 2010).

Extensive ship-based surveys of the entire US exclusive economic zone (EEZ) along the Pacific coast conducted since the early 1980s (with more extensive and consistent coverage since the early 1990s) have provided estimates of abundance and density for US waters of California, Oregon, and Washington, and in some cases information on abundance trends of certain species occurring there (e.g., Barlow 1995, 2003, 2010; Barlow and Forney 2007; Barlow and Gerrodette 1996; Barlow and Taylor 2001; Forney 1997, 2007; Forney and Barlow 1998). However, these surveys generally provide very coarse-scale data from a very large area, and generally do not provide the fine-scale precision that is required for the monitoring and analyses the Navy needs to conduct federally mandated environmental impact assessments and mitigation. Recently, some progress has been made in using the extensive datasets that have been accumulated over the last several decades to model densities, and thereby provide information that can be applied over smaller scales (see Barlow et al. 2009). However, models are notoriously susceptible to assumption violations, and paucity of data in certain areas weakens their real-world utility.

The waters off San Diego County, and especially the region around San Clemente Island, are heavily used by the Navy for various operations. These include training exercises involving low- and mid-frequency active sonars, which have been implicated in some cases as causing disturbance and even injury and mortality to some marine mammal species. Carretta et al. (2000) conducted extensive year-round aerial surveys of the area around San Clemente Island in 1998 and 1999. This information has been very relevant for Navy marine mammal resource management; however, the estimates are now over 13 years old and are out of date. Further, there is compelling evidence suggesting that the distribution and density of some marine mammal species has changed in the area. To effectively assess potential impacts of military activities that may cause disturbance or harm to marine mammals, and to implement effective mitigation measures to reduce or eliminate those impacts, updated data are needed on the seasonal density of marine mammal species occurring in the SCB. Our study was conducted to meet this goal as identified in the Navy's Southern California Marine Species Monitoring Plan (DoN 2009). As such, aerial surveys were conducted across the year to provide the most recent and comprehensive, up-to-date information available on marine mammal density and abundance in the SCB, focusing on the San Clemente Island region of most relevance to the Navy.

Methods

Data Collection

Surveys occurred from a small high-wing, twin-engine *Partenavia* P68-C or P68-OBS (glass-nosed) airplane following protocol similar to previous aerial surveys conducted to monitor marine mammals and sea turtles on behalf of the Navy in Hawaii and elsewhere (e.g., Mobley 2004, 2007, 2008a,b; Smultea and Mobley 2009; Smultea et al. 2009). Surveys occurred in October and November 2008; June, July and November 2009; and May, July and September 2010. The pilots were highly experienced with the voice reporting procedures for the Southern California (SOCAL) Range Complex as well as local and regional airspace. A Position-on-Demand (POD) GPS tracking device was installed on the observer aircraft so that it could be tracked by the Navy.

Survey effort involved four modes as described below (see **Table 1**):

1. *Search Mode* to locate and describe marine mammals and sea turtles via both *systematic* line-transect and *connector* aerial survey observation effort. Connector effort included observation effort between adjacent systematic transect lines and during transits to and from line transect locations.

2. *Identify* involving circling of the sighting to photo-document and confirm species, as possible, and to estimate group size and presence/minimum number of calves.
3. *Focal Follow* involving circling of a cetacean sighting to conduct extended behavioral observation sampling after species of interest is located.
4. *Shoreline Survey* involving circumnavigating clockwise around San Clemente Island ~0.5 km from shore to search for potentially stranded or near-stranded animals.

The pilot and three professionally trained marine mammal biologists (at least two with over 10 years of related experience) were aboard the aircraft. Two biologists served as observers in the middle seats of the aircraft and the third biologist was the recorder in the front right co-pilot seat.

Surveys were flown at altitudes of ~227-357 m (800-1,000 ft) following established line-transect survey protocol (see Carretta et al. 2000; Buckland et al. 2001; Mobley 2004, 2008a,b). In practice, however, altitude at the time of sightings ranged from 116-484 m, with an average of 261 ± 49 m. As feasible, line-transect design layout followed that of previous aerial surveys conducted 1-2 times per month over ~1.5 year in part of the survey area in 1998-99 by NMFS/SWFSC on behalf of the Navy (Carretta et al. 2000). Thus, as logistically feasible, transect lines were positioned primarily along a WNW to ESE orientation generally perpendicular to the bathymetric contours/coastline to avoid biasing of surveys by following depth contours (**Figure 1**). Transect lines described in Carretta et al. (2000) were spaced 22 km apart. Our transect lines were also spaced ~22 km apart between the coast and San Clemente Island (**Figure 1**). To the west and south of San Clemente Island our transect lines were spaced 11 km apart, given the goal to intensively survey in a prescribed area. Total distance surveyed in Beaufort 0-4 conditions was 12,206 km.

We used the following hardware and software for data collection including basic sighting and environmental data (e.g., Beaufort sea state, observation effort, glare, etc.): (1) BioSpectator on a Palm Pilot TX (pull-down menus or screen keyboard) or an Apple iPhone or iTouch in 2008 and 2009; or (2) a customized Excel spreadsheet on a mini-laptop Acer computer (2010). Each new entry was automatically assigned a time stamp and a sequential sighting number. Geographical Positioning System (GPS) locations were automatically recorded at 10-sec intervals on a Garmin 495 aviation WAAS-enabled GPS as well as by the aircraft WAAS GPS. Environmental data (involving various glare and visibility conditions) were collected at the beginning of each leg type and whenever conditions changed. GPS data were post-merged with sighting data using Excel.

One of three Canon EOS digital cameras with Image Stabilized (IS) zoom lenses was used to photo-document and verify species for each sighting as feasible/needed (40D with 100-400 mm ET-83C lens; 20D with 70-200 mm 2.8 lens and 1.4X converter; D50 with 100-400 mm lens). Observers used Steiner 7 X 25 or Swarovski 10 X 32 binoculars as needed to identify species, group size, behaviors, etc. A Suunto handheld clinometer was used to measure declination angles to sightings when the sighting was perpendicular to the aircraft.

Data Analysis

We used standard line transect methods to analyze the aerial survey data, and calculated estimates of density and abundance using the following formulae:

$$\hat{D} = \frac{n \ \hat{f}(0) \ \hat{E}(s)}{2 \ L \ \hat{g}(0)}$$

$$\hat{N} = \frac{n \ \hat{f}(0) \ \hat{E}(s) \ A}{2 \ L \ \hat{g}(0)}$$

$$C\hat{V} = \sqrt{\frac{\hat{\mathrm{var}}\,(n)}{n^2} + \frac{\hat{\mathrm{var}}\,[\hat{f}(0)]}{[\hat{f}(0)]^2} + \frac{\hat{\mathrm{var}}\,[\hat{E}(s)]}{[\hat{E}(s)]^2} + \frac{\hat{\mathrm{var}}\,[\hat{g}(0)]}{[\hat{g}(0)]^2}}$$

where D = density (of individuals),

n = number of on-effort sightings,

f(0) = trackline probability density at zero distance,

E(s) = unbiased estimate of average group size,

L = length of transect lines surveyed on effort,

g(0) = trackline detection probability,

N = abundance,

A = size of the survey area,

CV = coefficient of variation, and

var = variance.

Line transect parameters were calculated using the software DISTANCE 6.0, Release 2 (Thomas et al. 2010). Only survey lines flown during systematic (the main line transect survey lines) and connector (the connecting lines at the ends of the main lines) conditions were used to estimate line transect parameters. We used a strategy of selective pooling and stratification to minimize bias and maximize precision in making density and abundance estimates (see Buckland et al. 2001). Due to low sample sizes for most species, we pooled species with similar sighting characteristics in estimating the detection function [f(0)], with the goal of producing statistically robust values for f(0) using sample sizes of at least 40-60 sightings for each group. The four species groups were: 1) baleen whales, 2) large delphinids, 3) small dolphins, and 4) California sea lion (see **Table 2**).

We used all data collected in sea state conditions of Beaufort 0-4, and did not stratify estimates by sea state or other environmental parameters. We produced stratified (in terms of sighting rate and group size) estimates of density and abundance for the three survey subregions using the pooled f(0) species group values described above. The exception to this rule was for California sea lions, which had adequate sample size for estimation of f(0).

Since a significant proportion of sightings was unidentified to species (although most of these were identified to a higher-level taxonomic grouping, e.g., unidentified baleen whale, unidentified small dolphin, unidentified pinniped, unidentified *Balaenoptera* sp., or unidentified *Delphinus* sp.), we prorated these sightings to species using the proportions of species in the identified sample, and adjusted our sightings rates appropriately. To avoid potential overestimation of group size, we used the size-bias-adjusted estimate of average group size available in DISTANCE.

Truncation involved the most-distant 5% of the sightings for each species group. We also used left truncation at 250 m, due to indications that poor visibility below the aircraft resulted in missed detections near the transect line. We modeled the data with half-normal (with hermite polynomial and cosine series expansions), hazard rate (with cosine adjustment), and uniform (with cosine and simple polynomial adjustments) models, selecting the model with the lowest value for Akaike's Information Criterion.

We did not have data available to make empirical estimates of trackline detection [g(0)]. However, since our surveys were very similar to those of Carretta et al. (2000), values for g(0) from their study were used to correct for uncertain trackline detection. Estimates of density and abundance were produced only for those species with more than five useable, on-effort sightings in the line transect database.

Results

A total of 1,284 marine mammal groups were sighted during the surveys; however, 50 percent (n = 496) of these were made during off-effort periods for line transect, and thus could not be used to estimate density and abundance. There were 495 marine mammal sightings made during systematic and connector transects that were available to estimate density and abundance by line-transect methods (**Table 3**). The most commonly sighted species were blue whales (n=8), fin whales (n=26), Risso's dolphins (n=61), common bottlenose dolphins (n=11), Pacific white-sided dolphins (n=11), common dolphins (n=141), and California sea lions (n=127), and abundance was estimated for these species. Line-transect estimates of density and abundance (and their associated coefficient of variation) are shown in **Table 4**.

Identification of common dolphins to species level was often not possible during flights, and for this reason extensive photos were taken of common dolphin schools for later detailed examination. We examined a sample of these photos later to see if we could identify the species, and we could in many cases. Clearly, short-beaked common dolphins predominated, and based on preliminary sample of photos in which we able to determine species, 96% of common dolphins sighted were *D. delphis* and only 4% were *D. capensis*.

Discussion

Potential Biases of the Estimates

As is true of any statistical technique there are certain assumptions that must hold for line transect estimates of density and abundance to be accurate. Below we will describe the various assumptions of line transect and other issues that may cause bias in our estimates.

Assumption 1: Certain Trackline Detection

Target animals on and very near the trackline must be detected to avoid estimates that are biased low (Buckland and York 2009). This is a central assumption of basic line transect theory, but in reality it is often violated, especially by diving animals like marine mammals. However, this can be dealt with by incorporating a factor into the line transect equation that accounts the proportion of missed animals (the detection function, g(0)). We have done this in the present study, by use of g(0) factors from studies of diving behavior of the target species, but these only account for part of the potential bias (availability bias). Another fraction, termed visibility bias, represents the proportion missed despite the fact that they were available to be seen by the observers. This is much more difficult to model, and our estimates do not account for this, making them likely underestimates to some extent.

Assumption 2: No Responsive Movement

Although it often stated that there must be no responsive movement to the survey platform, this is not strictly true. However, any responsive movement must occur after detection by the observers, and such movement must be slow relative to the speed of the survey platform (Buckland and York 2009). In our case, the use of a fast-moving aircraft as survey platform minimizes the chances of this being a significant issue. This is much more of a concern with vessel surveys, and in aerial surveys is generally not considered to be a problem.

Assumption 3: No Distance Errors

It is quite obvious that distances must be measured accurately to avoid inaccuracies in the resulting estimates (Buckland and York 2009). However, in practice, distances are difficult to measure at sea, and it is likely that every marine mammal line transect survey has suffered from some inaccuracy in distance measurement. However, small and random errors generally do not cause significant problems. It is large and/or directional errors that are of serious concern. We have no indications that large or directional errors in distance measurement were an issue in this study.

Other Factors

Besides the above-listed issues, there are a few other factors that may cause some bias in resulting line transect estimates. Line placement, lack of independence of detections, and non-uniform distribution of animals can in some cases cause problems. But, these are generally not major issues and we believe that they are not factors in causing any significant bias in our estimates.

Placing the Estimates into Context

Historically, the patterns of cetacean relative abundance and presence in southern California waters are, in many cases, very different from what are currently observed. This is likely related to previous exploitation and depletion of these species and long-term changes in oceanographic conditions, and concomitant changes in prey distributions and densities. Peterson et al. (2006) summarized the anomalous conditions (including several El Niño and La Niña events) that have characterized the California Current System in the last several years. Below, we place the information obtained in the current study into the context of our historical knowledge.

Carretta et al. (2000) conducted extensive year-round aerial surveys of an overlapping (although not completely-so) area in 1998/1999. We followed very similar methods and used similar equipment to the surveys of Carretta et al. (2000), including the same aircraft. Our surveys mostly covered the period of the year defined by Carretta et al. (2000) as the warm-water period, and thus our estimates will most closely correspond to theirs from this period. Although, we cannot compare abundance estimates directly, since our study area boundaries differ somewhat, estimates of density for the Southern California Anti-Submarine Warfare Range (SOAR) and South of San Clemente Island overlap largely with the areas used by Carretta et al. (2000). Comparison to those estimates, in particular, can provide some useful information on potential changes in distribution and abundance of marine mammal species in the last 12-13 years.

Blue whale *Balaenoptera musculus*

Blue whales are relatively common off the coasts of southern and central California (Hamilton et al. 2009). Since protection was provided by the International Whaling Commission (IWC) in 1966, the eastern North Pacific stock is expected to be recovering from heavy exploitation by commercial whalers in the 20th century. The species is listed as Endangered under the Endangered Species Act (ESA). Cetacean surveys conducted in southern California waters in the 1950s did not mention the blue whale (Brown and Norris 1956; Norris and Prescott 1961). The best estimate of stock size is 2,842 whales (CV=0.41, Carretta et al. 2010). Despite this apparent increase, Carretta et al. (2010) found no evidence of an increasing trend in abundance from surveys in the last two decades. This may be partly related to high variance in inter-annual numbers of blue whales since blue whales appear to shift preferred feeding locations from year to year (Carretta et al 1995; Redfern et al. 2011).

Blue whales were observed nine times by Carretta et al. (2000), all but once during the warm-water season. A density of 0.47 animals/100 km^2 (CV=0.39) was calculated for the Carretta et al. (2000) surveys in the warm-water season. Our estimates (0-0.12 animals/100km^2) were all well below those of Carretta et al. (2000). However, it is known that feeding blue whales aggregate in different areas in various years. Thus, this may not be a good indication of long-term changes in abundance of this species along the San Diego coast.

Fin whale *Balaenoptera physalus*

The fin whale is one of the most common large whales off southern California and is present in all seasons (Carretta et al. 1995; Hamilton et al. 2009). Fin whales were protected by the IWC in 1976, and the population is predicted to have recovered somewhat. The fin whale was not mentioned in reports of cetacean surveys conducted in southern California waters in the 1950s (Brown and Norris 1956; Norris and Prescott 1961). The best estimate of stock size is 2,636 (CV=0.15, Carretta et al. 2010). The species is listed as Endangered under the ESA. Although there was some evidence of an increase from 1979-1996 (Barlow 1994, 1997), there is no evidence of a population increase in the California/Oregon/Washington stock from recent line transect surveys (Carretta et al. 2010). The effects of illegal whaling, as well as ship strikes and gillnet entanglement are considered possible reasons for this.

Carretta et al. (2000) sighted fin whales 21 times (six in the cold- and 15 in the warm-water season), which, compared to large whales, is ranked second only to the gray whale (sighted only in the cold-water season). Densities of 0.27 (CV=0.34, cold) and 0.89 (CV=0.33, warm) animals/100 km^2 were calculated from the Carretta et al. (2000) surveys. Our estimate for SOAR (1.22 animals/100 km^2) is similar to their warm-water estimate, although our estimate for the Northern Air Operating Area (NAOPA) (0.18 animals/100 km^2) is much lower. Despite a lower estimate, fin whales are clearly the most common and abundant large whales in the study area during the warm-water months, and a significant number of these whale (n = 66) appear to use the study area at this time of year.

Sei whale *Balaenoptera borealis*

Sei whales are not commonly observed off California, although it is clearly part of their normal range (see Barlow 1994; Hamilton et al. 2009). Their range and migration patterns are not fully understood, though they clearly prefer oceanic waters and are not often seen in coastal regions (Horwood 1987). Sei whales often appear to have an erratic or 'irruptive' pattern of movements: they occur in a feeding area for a period of time then virtually disappear, apparently moving elsewhere (Jonsgard and Darling 1977; Horwood 1987; Schilling et al. 1992). There is no reliable abundance estimate for the Eastern North Pacific stock. The best estimate of numbers off the US west coast is only 46 whales (CV=0.61), which is likely a vast underestimate (Carretta et al. 2010). Although the species is listed as Endangered under the ESA, nothing specific is known of trends for this stock. This species was not sighted in the Carretta et al. (2000) surveys. The single sighting in the current study was considered insufficient for making a reliable abundance estimate.

Bryde's whale *Balaenoptera edeni/brydei*

Bryde's whales are very uncommon off the California coast (Hamilton et al. 2009). Although they are common further south off southern Baja California, in the Gulf of California, and in the eastern tropical Pacific, only two confirmed records of this species are known from the US west coast. A sighting was made off La Jolla in 1963 (Morejohn and Rice 1973), and another sighting was made during a SWFSC survey in offshore waters (ca. 36°N) in fall 1991 (Hill and Barlow 1992; Barlow 1995; Hamilton et al. 2009). There is no stock recognized for US west coast waters, and records from this area have generally been considered extralimital wanderings of stocks further south off Mexico and the eastern tropical Pacific (Carretta et al. 2011). Carretta et al. (2000) did not observe Bryde's whales in their surveys. The single sighting in this study was considered insufficient for making a reliable abundance estimate.

Common minke whale *Balaenoptera acutorostrata*

Although minke whales are reasonably common off the California coast, they are not often observed on visual surveys (Hamilton et al. 2009). These animals have a low surfacing profile, an often invisible or indistinct blow, and can easily be missed by visual observers (see Rankin et al. 2007). The California/Oregon/Washington stock of minke whales is currently thought to number 806 animals (CV=0.63, Carretta et al. 2010). There are no data on trends in abundance. Carretta et al. (2000) only observed a single group in their surveys, and provided an estimated density of 0.095 animals/100 km^2 (CV=0.91). Only four sightings occurred in the current study, and so no estimates of density or abundance were attempted.

Humpback whale *Megaptera novaeangliae*

Humpback whales were depleted off the California coast by shore-based whaling in two phases: first before 1925 and again between 1956 and 1965 (Carretta et al. 2010). These animals feed off the California coast and have become very common in many areas of central and northern California in the last couple of decades (Hamilton et al. 2009). They are now seen regularly in southern

California. The single stock recognized in US west coast waters is the California/Oregon/ Washington stock, which breeds mainly in Mexican waters (Carretta et al. 2010). The best estimate of stock size is 1,391 (CV=0.13, Carretta et al. 2010). The species is listed as Endangered under the ESA, and therefore is considered depleted under the ESA. However, NMFS is currently considering delisting or downlisting this species given indications of a strong recovery for North Pacific populations over the last several decades (Carretta et al. 2010).

Carretta et al. (2000) sighted humpback whales twice in their surveys, both times in the cold-water season. A density of 0.15 (CV=0.46) animals/100 km^2 was calculated from the Carretta et al. (2000) surveys for the cold-water season. We only observed five groups of humpback whales, and this was considered insufficient for estimating their abundance.

Cuvier's beaked whale *Ziphius cavirostris*

While Cuvier's beaked whales are probably reasonably common off the coast of California, this species is infrequently observed on visual sighting surveys (Hamilton et al. 2009). As with all beaked whales, this may have much more to do with their long dives, low surfacing profile, and cryptic habits than with actual rarity. Nothing is known about population trends for the California/Oregon/Washington stock, which is thought to number about 2,830 (CV=0.73, Carretta et al. 2010). A recent study using a combination of visual and acoustic techniques to locate *Ziphius* groups suggested that the deeper-water region west of San Clemente Island is an important area for this species (Falcone et al. 2009). This region may have great potential to aid in investigations of impacts of military sonar on beaked whales.

Carretta et al. (2000) observed Cuvier's beaked whales three times (all in the cold-water season) and calculated a density of 1.9 animals/100 km^2 (0.52) from their surveys off San Clemente Island. Only four sightings were made in the current study, and so no estimates of abundance were attempted.

Killer whale *Orcinus orca*

Killer whales are observed relatively infrequently off the coast of southern California (Hamilton et al. 2009). There are several stocks along the California coast, and animals observed around San Clemente Island would most likely be from the Eastern North Pacific Offshore stock. This stock is currently estimated to number at least 353 individuals, and nothing is known about the trend in the population (Carretta et al. 2010). This species was not seen in the surveys conducted by Carretta et al. (2000). We only observed killer whales twice, so no estimates of density or abundance were attempted.

Risso's dolphin *Grampus griseus*

Currently one of the most common species of delphinids off the coast of California (Hamilton et al. 2009), Risso's dolphins have apparently undergone significant changes in numbers and/or distribution over the last several decades (Kruse et al. 1999). Older reports from the middle of the 20th century did not identify these animals as common. In fact, they were not even mentioned by Brown and Norris (1956) and Norris and Prescott (1961), who conducted extensive cruises in the Southern California Bight in the 1950s. Similarly, Risso's dolphins were not discussed by Walker (1975), who conducted many searches in the Southern California Bight, in 1966-1972 for the purpose of live-capture of small cetaceans. Leatherwood et al. (1980) stated that the periods of greatest abundance in southern California were associated with periods of protracted warm water, and they considered the Risso's dolphin to be primarily a tropical species. Our current understanding of this species does not support this view, as areas of greatest abundance generally appear to be areas with colder waters, such as central California.

The California/Oregon/Washington stock of Risso's dolphin is currently thought to number 11,621 individuals (CV=0.17), and there is no empirical evidence of an overall trend in abundance from recent line-transect surveys conducted off the US west coast (Carretta et al. 2010). Risso's were common in the late 1990s, when the Carretta et al. (2000) surveys were conducted, and those authors observed 23 groups (16 of them during the cold-water season). They calculated densities of 18.0 (CV=40, cold) and 6.1 (CV=56, warm) individuals/100 km^2. Our calculated densities for NAOPA and South of San Clemente Island (19.99 and 16.01 animals/100 km^2) are much higher than those for Carretta et al.'s (2000) warm season, but similar to those they estimated for the cold season. These densities indicate that a substantial number of Risso's dolphins used the area during the study period (n = 2,537 individuals) making them the second-most abundant species after common dolphins. Although this may be partly due to the larger proportion of shallower waters in our study area (continental shelf and upper slope waters are preferred by this species), it is probably also indicative of increased use of the San Diego area during the warmer months.

Common bottlenose dolphin *Tursiops truncatus*

The NMFS currently recognizes two stocks of bottlenose dolphins in southern California. The coastal stock does not venture over 1 km from the mainland shore. Thus animals observed in the present study around San Clemente Island would presumably be mostly members of the California/Oregon/ Washington stock. These offshore bottlenose dolphins present in California may actually comprise more than one stock, and there is some evidence of separate island-associated populations, but this has not yet been confirmed. Nevertheless, the currently recognized offshore (California/Oregon/Washington) stock is estimated to number 3,495 individuals and there is no information on trends for this stock (CV=0.31, Carretta et al. 2010).

Older records of bottlenose dolphins in more offshore waters of southern California usually stated that they were almost always in the company of short-finned pilot whales (Norris and Prescott 1961; Walker 1975). Pilot whales were previously considered to be "quite common" in southern California waters (Brown and Norris 1956). This association was not seen in the present study, as pilot whales were never observed.

Bottlenose dolphins were seen by Carretta et al. (2000) in both warm- and cold-water seasons, and densities of 3.4 (CV=0.66, cold) and 1.5 animals/100 km^2 (CV=0.67, warm) were estimated from their surveys in the late 1990s. Our estimate of 6.92 animals/100 km^2 for NAOPA is somewhat higher, which is expected for this coastal area. Bottlenose dolphins generally have higher densities in shallow, coastal waters.

Short-beaked common dolphin *Delphinus delphis*

Until 1994, only a single species of common dolphin was considered to occur off the California coast, *D. delphis* (Heyning and Perrin 1994). We now know that there are actually two species, *D. delphis* and *D. capensis,* and that before 1994 the two species were erroneously lumped as *D.*

delphis. Work conducted before the mid-1990s did not distinguish the two species, but conclusions from these studies are probably mainly attributable to the more-abundant short-beaked species. This species has long been known as one of the most abundant in the Southern California Bight (Brown and Norris 1956; Norris and Prescott 1961; Walker 1975; Dohl et al. 1986; Hamilton et al. 2009). Although older records are sometimes contradictory (e.g., Brown and Norris 1956; Norris and Prescott 1961), extensive aerial surveys for common dolphins in the 1980s showed them to be much more widespread and with much higher densities (0.8-2.4 individuals/km²) in summer/autumn months than during winter/spring (0.2-1.2 individuals/km² – Dohl et al. 1986). The latter authors identified an influx of animals from the south into the bight in the warm-water months.

Short-beaked common dolphins are extremely common in southern California waters. The population currently numbers an estimated 392,733 individuals (CV=0.18), making it the most abundant cetacean in the Southern California Bight (Carretta et al. 2010). There is good evidence of an increasing trend in the southern California waters, and this may be correlated with a decline in numbers of 'northern common dolphins' (which includes both species) in Mexican waters and the eastern tropical Pacific.

The short-beaked common dolphin was the most-frequently observed cetacean species during the Carretta et al. (2000) study. Short-beaked common dolphins were observed in both seasons, with estimated densities of 178.0 (CV=0.37, cold) and 465.0 (CV=0.39, warm) animals/100 km². We observed both species of common dolphins in our surveys. However, *D. delphis* comprised 96% of 13, 673 identified individuals, so the estimates below primarily refer to *D. delphis*. Densities of common dolphins in our study were lower than for Carretta et al.'s warm-water season (318.99 animals/100 km² in NAOPA and 58.43 animals/100 km² in SOAR). This may be at least partly related to cooler water temperatures in recent years (for instance 2010 was a La Niña year, with unseasonably, cool water temperatures). However, short-beaked common dolphins were still very abundant in the study area (the most abundant species, by far) with an estimated 29,044 individuals present.

Long-beaked common dolphin *Delphinus capensis*

The long-beaked species of common dolphin is frequently observed in nearshore waters of southern California, within 50 nm from the coast (Hamilton et al. 2009; Carretta et al. 2010). There is not much information on the historical status of this species, since it was not recognized as a separate species until 1994 (Heyning and Perrin 1994). The California stock of the long-beaked common dolphin is currently estimated to number 15,335 individuals (CV=0.56). There is nothing known about the overall population trends for this species. Oceanographic conditions (especially warming of local waters during El Niño conditions) cause fluctuations in the densities of these dolphins in the Southern California Bight (Heyning and Perrin 1994; Carretta et al. 2010).

Carretta et al. (2000) did not report any sightings of this species during their late-1990s surveys, and all identified common dolphins in that survey were considered to be *D. delphis* (J. Carretta, pers. comm., Dec. 2010). We did observe several groups of long-beaked common dolphins, although they were much less frequent and in much smaller groups than short-beaked common dolphins. Based on our estimates that only 4% of common dolphins in our study would be *D. capensis*, we estimate about 900 long-beaked common dolphins for NAOPA, 75 for SOAR, and 15 for the South of San Clemente Island areas.

Pacific white-sided dolphin *Lagenorhynchus obliquidens*

Pacific white-sided dolphins have long been recognized as one of the most abundant cetaceans in southern California waters (Brown and Norris 1956; Norris and Prescott 1961; Walker 1975; Leatherwood et al. 1984). They are relatively common in the Southern California Bight during the cold-water season, as they move inshore in the winter and spring months (Brown and Norris 1956; Norris and Prescott 1961; Leatherwood et al. 1984; Hamilton et al. 2009). Currently, two geographic forms/populations are known off the US west coast, a northern and a southern form. These are based on subtle differences in morphology and genetics, but no reliable indicators have been identified that would allow individuals seen at sea to be referred to a specific form (Walker et al. 1986; Carretta et al. 2010). Due to the inability to reliably distinguish animals from the two stocks in surveys, only a single stock is currently recognized by NMFS for management purposes (Carretta et al. 2010). An estimated 20,719 dolphins (CV=0.22) of this species occur off California, Oregon, and Washington (including animals of both stocks). There is no indication of a long-term trend in abundance for these animals off the US west coast. The Southern California Bight represents an area of potential overlap of both forms. Thus, it is not clear to which stock animals sighted in this study would belong.

In the Carretta et al. (2000) surveys, Pacific white-sided dolphins were only seen in the cold-water season. There were 26 sightings, and a density of 19.7 individuals/100 km^2 (CV=0.44) was calculated. We observed this species several times in our surveys during the warm-water season, and densities of 0.53 and 2.15 individuals/100 km^2 were calculated for NAOPA and SOAR, respectively – much lower than the cold-water estimates of Carretta et al (2000). This may indicate increased use of the San Diego area by the species during our warm-water study period; it may also be related to unseasonably cool water temperatures experienced during at least some recent surveys (especially 2010).

Northern right whale dolphin *Lissodelphis borealis*

The northern right whale dolphin has traditionally been considered one of the two or three most abundant cetacean species in southern California waters (Norris and Prescott 1961; Leatherwood and Walker 1979; Carretta et al. 1995; Hamilton et al. 2009). They occur in the Southern California Bight primarily during periods of cold-water temperatures and highest squid abundance; they move north when water temperatures increase, especially during late spring and summer months (Leatherwood and Walker 1979; Carretta et al. 2010). A single stock is recognized in US waters, the California/Oregon/Washington stock. The current best estimate of abundance for this stock is 12,876 individuals (CV=0.30), and there is currently no evidence of any significant trend in numbers (Carretta et al. 2010).

In surveys conducted by Carretta et al. (2000) around San Clemente Island, northern right whale dolphins were only observed in the cold-water season. There were 11 sightings, yielding a density of 9.0 individuals/100 km^2 (CV=0.40). The two sightings of this species obtained in this study were considered insufficient for estimating density or abundance.

California sea lion *Zalophus californianus*

California sea lions are very common in waters of southern California, and are the most abundant pinniped species along the coast of California. A single US stock is recognized, and the current best estimate of stock size is 238,000 individuals (Carretta et al. 2010). The population has been generally increasing for many decades, although there have been several dips in abundance in recent years. The population is believed to have reached carrying capacity, though this cannot currently be confirmed (Carretta et al. 2010). In-water densities of California sea lions have traditionally not been estimated before in southern California, although Carretta et al. (2000) provided the first such estimates based on several hundred sightings. Their estimates ranged from 19.4 to 119.0 animals/100 km^2 in the cold-water season, and from 5.6 to 75.0 animals/100 km^2 in the warm-water season. Our estimates ranging from 5.74-31.08 individuals/100 km^2 are in general agreement though somewhat lower. A total of 2,534 California sea lions were estimated to be at sea in the study area during our study. The lower density in our study may be expected, as our surveys did not have extensive coverage in the nearshore shallow waters, where California sea lions are most frequently observed (Carretta et al. 2000 did, however). Density at sea tends to be lower during the summer months, when much of the population is on the island for the breeding season. Carretta et al. (2000) counted as many 3,941 California sea lions hauled out on San Clemente Island in April 1999.

Northern elephant seal *Mirounga angustirostris*

There is a single stock of the northern elephant seal in US waters, the California breeding stock. These animals are common in the Southern California Bight, and they breed on the California Channel Islands. In 2005, the California breeding stock was estimated at 124,000 seals. Births have been rapidly increasing since at least 1960, and the population is considered to have not yet reached its carrying capacity (Carretta et al. 2010). The five sightings made in this study were considered insufficient for making a reliable density or abundance estimate.

Harbor seal *Phoca vitulina*

Common in waters of southern California, the harbor seal comprises several stocks in US west coast waters. The California stock is currently estimated to number 34,233 individuals. It is still increasing overall, but it is thought that it is approaching carrying capacity (Carretta et al. 2010). Only three sightings were obtained in the current study, so no estimates of abundance were attempted.

Conclusions

This study has provided the only available recent estimates of density or abundance for marine mammal species in the majority of coastal and offshore waters off of San Diego. Our results are in general agreement with those of Carretta et al. (2000), who surveyed a largely overlapping area using similar methods in the late 1990s. Our results indicate that the study area continues to be used by a substantial number of marine mammal species during the warm-water season. However, numerically the region is dominated by only a few species. For great whale species (i.e., blue and fin), abundance was estimated to be in the tens. Pacific white-sided and bottlenose dolphins numbered in the hundreds, and Risso's and common dolphins, as well as California sea lions, numbered in the thousands. Other species were not seen frequently enough to calculate useful abundance estimates, but in some cases may actually be reasonably abundant, at least in some parts of the year. We have recently conducted several additional surveys in the cold-water winter and spring months, and we hope to calculate year-round estimates of density and abundance for a larger set of species based on much larger sample sizes in the future.

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Table 1. Description of the four primary study modes designed to address monitoring goals of the aerial survey.

Mode	Aircraft Speed (kt)	Aircraft Altitude (m)	Flight Pattern	Duration	Data Collected
Search	~100	~305	• Systematic transect lines • Random shorter connecting lines • Transits	Until MM or ST seen, then switch to Identify or Focal Follow Mode	• Time & location of sighting • Species, group size, % calves • Bearing & declination angle to sighting • Behavior state • Initial reaction (yes or no & type) • Status (alive or dead) • Heading of sighting (magnetic) • Dispersal distance (min. & max. in estim. body lengths)
Identify	~85	~305	Circling at ~305 m radius	<5 min	• Photograph to verify species • Estimate group size, % calves • Note any apparent reaction to plane or unusual behavior
Focal Follow	~85	~365-457	Circling at ~1 km radius	≥5– 60+ min	<u>In order of priority every ~1 min:</u> • Time • Focal group heading (magnetic) • Lat. /long. (automatic GPS) • Behavior state • Dispersal distance • Aircraft altitude (ft) • Distance of aircraft to MM (declination angle) • Reaction? • Individual aerial behavior events • Bearing & distance to vessels <10 km away or other nearby activity • Surface & dive times (whales) • Individual respirations (whales)
Shoreline Survey	~100	~305	Circumnavigate San Clemente Island in clockwise direction ~0.2 km from shoreline (random effort)	~45 min	• Status (alive, dead or injured) • Species, group size, % calves/young • Bearing & declination angle to sighting • Behavior state & heading • Initial reaction?

Table 2. Estimates of the detection function for the four species groups.

Species Group	Species Included	n	f(0)	%CV
Baleen whales	*B. musculus, B. physalus, B. borealis, B. edeni, B. acutorostrata, Balaenoptera* sp., *M. novaeangilae*	60	0.7881	9.27
Large delphinids	*G. griseus, T. truncatus, O. orca*	74	2.2332	6.44
Small dolphins	*D. delphis, D. capensis, Delphinus sp., L. obliquidens, L. borealis*, unid. small dolphin	193	1.3698	9.08
CA sea lion	*Z. californianus*	127	8.4030	21.57

Table 3. Marine mammal species observed during the surveys, with total sightings (nT), sightings used in line transect estimation (nD), and months observed. (Surveys were flown in months 5-11).

SPECIES	nT	nD	Months Observed
Blue whale - *Balaenoptera musculus*	50	8	5, 6, 7, 8, 10, 11
Fin whale - *Balaenoptera physalus*	51	26	5, 6, 7, 10, 11
Sei whale - *Balaenoptera borealis*	1	0	9
Bryde's whale - *Balaenoptera brydeii/edeni*	1	1	9
Common minke whale - *Balaenoptera acutorostrata*	5	3	5, 7, 9, 11
Humpback whale - *Megaptera novaeangliae*	5	5	6, 11
Cuvier's beaked whale - *Ziphius cavirostris*	4	2	7, 9, 11
Killer whale - *Orcinus orca*	2	2	11
Pacific white-sided dolphin - *Lagenorhynchus obliquidens*	21	11	5, 7, 11
Risso's dolphin - *Grampus griseus*	157	61	5, 6, 9, 10, 11
Common bottlenose dolphin - *Tursiops truncatus*	27	11	5, 6, 7, 9, 10
Short-beaked common dolphin - *Delphinus delphis*	35	19	10, 11
Long-beaked common dolphin - *Delphinus capensis*	10	2	6, 9, 10, 11
Common dolphin - *Delphinus* sp.	299	120	5, 6, 7, 9, 10, 11
Northern right whale dolphin - *Lissodelphis borealis*	3	2	6
California sea lion - *Zalophus californianus*	300	127	5, 6, 7, 9, 10, 11
Harbor seal - *Phoca vitulina*	13	1	7, 10, 11
Northern elephant seal - *Mirounga angustirostris*	6	5	5, 9, 11
Unid. baleen whale	19	17	6, 7, 9, 11
Unid. dolphin	161	39	5, 6, 7, 9, 10, 11
Unid. pinniped	45	17	5, 6, 7, 10, 11
Unid. marine mammal	24	16	5, 6, 7, 11
TOTAL	1,239	495	

Table 4. Estimates of individual density (Di), abundance (N), and coefficient of variation (%CV) for marine mammals in the SoCal area.

SPECIES	Di	N	%CV	TOTAL N
Blue whale - *Balaenoptera musculus*				**13**
NAOPA	0.00124	11	40.73	
SOAR	0.00047	2	99.83	
South of SCI	0	0		
Fin whale - *Balaenoptera physalus*				**66**
NAOPA	0.00177	15	56.67	
SOAR	0.01219	51	33.90	
South of SCI	0	0		
Pacific white-sided dolphin - *Lagenorhynchus obliquidens*				**135**
NAOPA	0.00530	45	100.67	
SOAR	0.02154	90	86.50	
South of SCI	0	0		
Risso's dolphin - *Grampus griseus*				**2,537**
NAOPA	0.19985	1,693	31.70	
SOAR	0.01403	59	85.30	
South of SCI	0.16006	785	110.95	
Common bottlenose dolphin - *Tursiops truncatus*				**585**
NAOPA	0.06915	585	72.43	
SOAR	0	0		
South of SCI	0	0		
Common dolphins - *Delphinus* spp.				**30,034**
NAOPA	3.18990	27,028	36.20	
SOAR	0.58430	2,442	52.60	
South of SCI	0.11505	564	61.70	
California sea lion - *Zalophus californianus*				**2,534**
NAOPA	0.11240	952	43.00	
SOAR	0.31082	1,300	63.70	
South of SCI	0.05743	282	108.81	

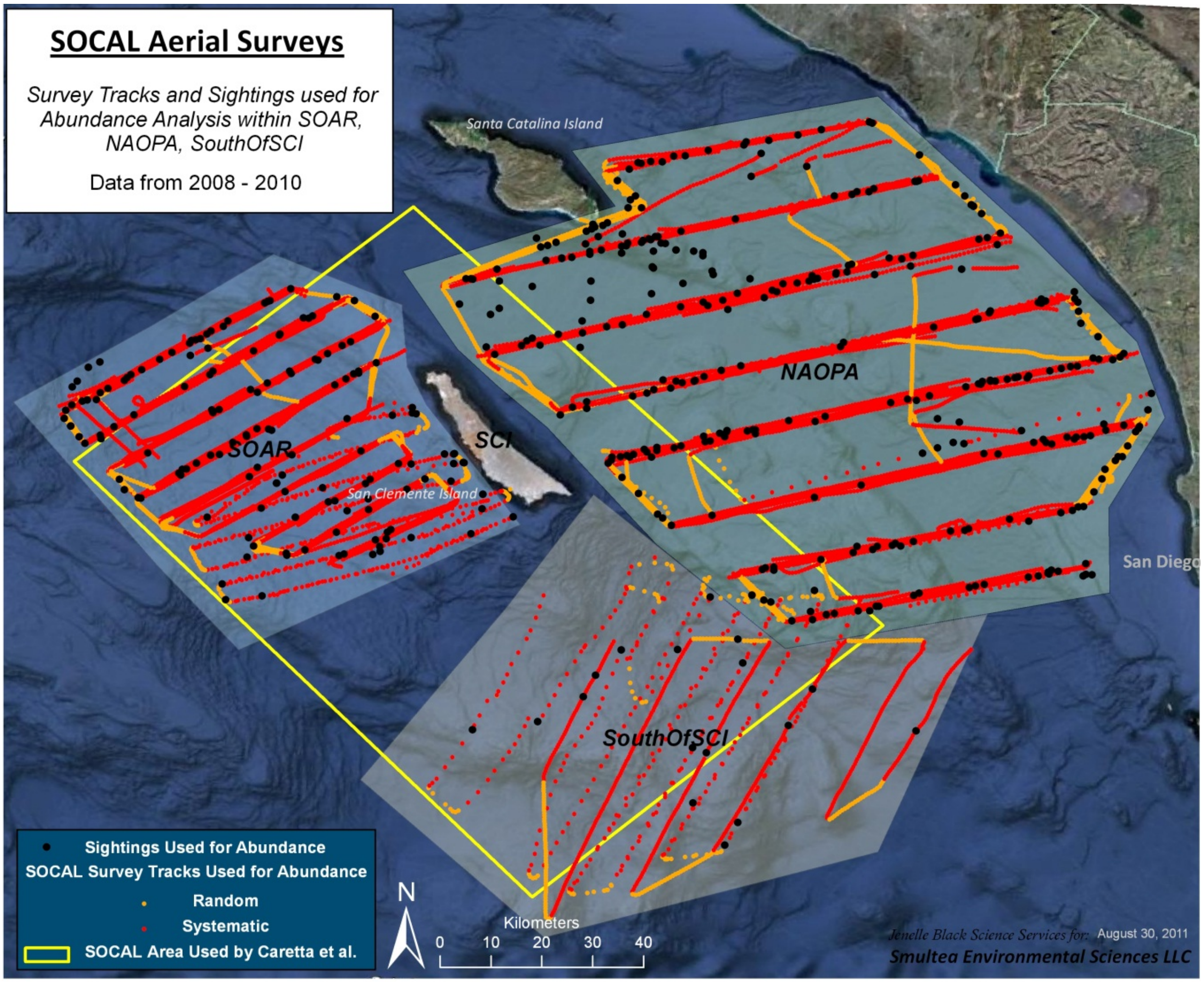

Figure 1. Survey tracks from surveys during 2008- 2010.

BEHAVIOR AND GROUP CHARACTERISTICS OF MARINE MAMMALS IN THE SOUTHERN CALIFORNIA BIGHT 2008-2010

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Introduction

The observed behavior of marine mammals in the Southern California Bight (SCB) has been little described and is limited to a few species and relatively small sample sizes. Since 2008, the U.S. Navy has been tasked by the National Marine Fisheries Service to monitor the distribution, occurrence and behavior of marine mammals within the Southern California Range Complex (SOCAL) off San Diego and San Clemente Island, California (DoN 2009). The initial primary goal has been to gather current baseline data that can be used comparatively to quantify potential effects of Navy major training events involving mid-frequency active sonar (MFAS) and underwater detonations. Numerous behavioral and group social parameters have been used to quantify and compare the reactions of various marine mammal species to anthropogenic and other stimuli such as underwater sound, vessels, predators, etc. (e.g., see review in Richardson et al. 1991). In such studies, baseline variables were compared to the same variables collected under stimulus-exposed conditions. Significant changes in a number of behavioral variables have been associated with such stimuli for whales. Examples include changes in dive and surface times, respiration rates, swim speeds, and headings among bowhead whales (*Balaena mysticetus*) (e.g., Richardson et al. 1985), gray whales (*Eschrichtius robustus*) (Malme et al. 1986), humpback whales (*Megaptera novaeangliae*)(Baker et al. 1985; Bauer 1986, Frankel and Clark 2002), and sperm whales (*Physeter macrocephalus*) (Madsen et al. 2002; Smultea et al. 2008). Among delphinids, reactions have included changes in dive and surface times, group size and cohesion, heading/orientation, swim speed, including bottlenose dolphins (*Tursiops truncatus*) (Smultea and Würsig 1992; Constantine et al. 2004), dusky dolphins (*Lagenorhynchus obscurus*) (Vaughn et al. 2010), and common dolphins (*Delphinus* spp.) (Stockin et al. 2009).

Of particular relevance to SOCAL are recent studies there and elsewhere focused on the behavioral responses of a number of cetacean species to playbacks of reduced sound levels of MFAS. The latter studies have been designed to facilitate collection of before, during and after behavioral, dive and vocalization data. Techniques have included vessel-based visual observations, passive acoustic recordings, photo-identification, and tagging of animals with satellite, time-depth-recorder, and acoustic sensors. However, vessels from which visual observations are made contribute to underwater noise and potential confounding disturbance to focal animals. In addition, the high expense of such studies, the difficulty in obtaining statistically sufficient sample sizes, and the general lack of baseline "undisturbed" regional behavioral data from SCB species limits the interpretation of the results. Despite the limitation, those studies currently represent the most integrated and comprehensive study focused on the behavioral responses to MFAS. Preliminary results indicate that responses or lack thereof appear to be related to the behavioral context when the noise exposure occurs, i.e., the level of individual response is related to what the individual is doing as has been shown for other cetaceans and stimuli (reviewed in Richardson et al. 1991). Although these studies have provided valuable insight, there is still a critical need for additional behavioral response studies, particularly with larger sample sizes and from other species (NRC 2003; Southall et al. 2008). Additionally, to interpret these results, it is also essential to understand what constitutes “normal” or “typical” behavior in the absence of the noise of interest which is difficult, if not impossible to obtain from vessel-based visual observations.

In this paper, we report selected results of aerial surveys conducted in the SCB on behalf of the Navy to gather baseline behavioral ecology parameters for marine mammals with which to provide a comparison database for animals exposed to MFAS. Variables of interest were selected based on results of other studies identifying certain quantifiable parameters shown to be demonstratively sensitive to underwater noise for some marine mammal species (e.g., Richardson et al. 1985, 1995; Malme et al 1986; Smultea and Würsig 1992; Gailey et al. 2007). The goal was to gather robust sample sizes of the selected behavioral and group characteristic variables to describe the typical behavior of Federally-listed and selected priority species as feasible. We also developed hypotheses linked with these variables to be used for future and ongoing identification and interpretation of potential reactions of marine mammals to MFAS and underwater detonations.

Methods

Eight aerial surveys were conducted from 2008-2010 in October and November 2008; June, July and November 2009; and May, July and September 2010 (Table 1). The observation platform was a high-wing, twin-engine, fixed-wing Partenavia P68 or Observer (OBS) aircraft. Survey methods were consistent with current accepted Distance Sampling theory (Buckland et al. 2001) and followed general protocol used for surveys SOCAL (e.g., Carretta et al. 2000). Survey lines consisted of generally E-W-oriented lines perpendicular to bathymetric contours (Figure 1). Surveys were flown at a speed of 100 knots from an altitude of approximately 357 m (1,000 ft). Previous studies indicate that bowhead whales (e.g., Richardson et al. 1985a,b; Patenaude et al. 2002), adult humpback whales (e.g., Smultea et al. 1995), and bottlenose dolphins (Smultea and Würsig 1995) show little or no detectable reaction to small fixed-wing aircraft circling at these altitudes and radial distances (also see review in Richardson et al. 1985 a,b; 1995). Preliminary data support these results (SES unpublished data). These parameters are well outside the Snell’s Cone theoretical range of air-to-water sound transmission angle associated with over-flying aircraft (Urick 1972, 1983; Richardson et al. 1995). Thus, staying outside these parameters was anticipated to avoid the potential for the aircraft to affect the behavior of the observed animals.

The survey team consisted of a pilot and three marine mammal biologists experienced in line-transect survey methodology; identification of Pacific marine mammals; and marine mammal observations from aircraft. Two observers were in the back seats of the aircraft, while the third sat in the front right co-pilot seat, serving as the recorder and photographer.

The general survey approach was to: (1) follow survey lines until a sighting was made; (2) record basic sighting information per established protocol; and (3) circle the sighting to photo-document and confirm species and group size and take digital photographs as needed; or (4) increase altitude to ~365-455 m and radial distance ~0.5-1.0 km to conduct a detailed focal behavioral follow involving videography. Geographical Positioning System (GPS) locations were automatically recorded at 10-sec intervals on a handheld, WAAS-enabled Garmin 495 aviation

GPS as well as by the aircraft WAAS GPS. A Suunto handheld clinometer was used to measure declination angles to a sighting when it was perpendicular to the aircraft. Steiner 7 x 25 or Swarovski 10 x 32 binoculars were used as needed to identify species, group size, and behaviors.

Data were recorded using a Palm Pilot TX, Apple iTouch, or an Acer netbook laptop computer. Data recording software consisted of SpectatorGo or custom-designed Excel datasheets. Recorded variables included environmental data (Beaufort sea state, glare, visibility conditions); leg effort type (e.g., systematic line transect, connector (i.e., shorter) lines connecting systematic lines, random, transect, circling); species; estimated group size; and number of calves observed. Modified scan sampling and zero-one sampling approaches (Altmann 1974; Smultea 1994, 2008; Mann 2000) were used to record: (1) behavioral state; (2) minimum and maximum dispersal distance between nearest individuals within a subgroup (i.e., spacing estimated in body lengths [BL]); and (3) heading (in degrees magnetic) (see Table 2).

Photographs to confirm species identifications were taken using a digital camera with Image Stabilized (IS) zoom lenses (a Canon 40D with 100-400 mm ET-83C lens, a 20D with 70-200 mm 2.8 lens and 1.4x converter; or a D60 with 100-400mm lens). For focal follow behavioral sessions, a Canon Vixia HF10 or Sony HDR-XR550 12.0 megapixels high-definition (HD) digital video camera with a built-in optical image stabilizer and 12x optical zoom lens were used to record behaviors. Software vATS was used to convert video camera lapsed time to real-time. The microphone of the video camera was connected to the audio system of the aircraft so that all vocal input (i.e., behavioral verbal descriptions) was recorded into the video camera data stream.

Sighting rates (number of sightings per unit effort) were calculated for on-effort periods involving “point-to-point” effort (i.e., systematic, connector and transit leg types) (Smultea et al. 2009, Jefferson et al. 2011). Statistical analyses were conducted using Excel or SPSS software. Video analyses involved reviewing video and transcribing observed behaviors and recorded audio from the video onto a customized Excel spreadsheet (Smultea and Bacon 2011); the latter results are not includedhere.

Results

A total of 1,284 groups of marine mammals and an estimated 177, 770 individuals were sighted during approximately 37,798 km of all observation effort across eight aerial surveys from Fall 2008 through Fall 2010 (Table 1). Of these totals, 24,736 km consisted of point-to-point observation effort during which 924 sightings of approximately 85,502 individuals occurred. Sixteen marine mammal species were identified-- 13 cetacean and 3 pinniped (Table 1). Group size and initial behavioral state, heading, and minimum and maximum dispersal distance (within subgroups) data were recorded for most sightings when such information could be determined. Sighting rates, mean group sizes, and means and/or frequency distributions of headings, mean maximum dispersal distance, and behavior states are presented in Tables 2-4 and Figures 2-43; these parameters were also summarized by time of year and diurnal differences.

The following discussion is organized by species or species groups in descending order of group sighting frequency and is limited to the following seven most commonly sighted species each with a minimum of 20 sightings: common dolphin, California sea lion, Risso's dolphin, fin whale, blue whale, bottlenose dolphin, and Pacific white-sided dolphin. Sample sizes of the remaining species were considered too small to warrant summarization and interpretation of trends. Each subsection consists of a brief overview of natural history important to understanding the context of the study results. Results are then discussed in the context of what is known and of relevance for the species, and what those results may indicate relative to the animal's behavioral ecology. In general, the social behavior of the species discussed is not well documented and/or what is available has been collected outside the SCB with few exceptions.

Common Dolphin *Delphinus* spp.

Two species of common dolphin – short-beaked (*D. delphis*) and long-beaked (*D. capensis*) – occur in the SCB (Heyning and Perrin 1994; Chivers et al. 2010; Carretta et al. 2011). Common dolphins are the most abundant cetaceans off California (e.g., Dohl et al. 1981; Forney et al. 1995; Carretta et al. 2011; Jefferson et al. 2011). Historically, this abundance has changed both seasonally and inter-annually with varying oceanographic conditions, with abundance increasing off California during the warm-water months (Dohl et al. 1986; Barlow 1995; Forney et al. 1995; Forney and Barlow 1998; Forney 2000; Carretta et al. 2011). In response to oceanographic events, movements may be north-south and/or inshore-offshore (Barlow 1995; Forney and Barlow 1998). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s, suggesting a large-scale shift in distribution in the eastern North Pacific (Forney et al. 1995; Forney and Barlow 1998; Jefferson et al. 2011). The northward extent of this distribution appears to vary interannually and with changing oceanographic conditions (Forney and Barlow 1998).

Delphinus is often found associated with offshore bathymetric features, such as escarpments and submarine canyons (e.g., Dohl et al. 1986). However, common dolphins of both species have also frequently been found close to the SCB mainland (Smultea et al. 2009, 2010, 2011a). Perrin (2002) report that long-beaked common dolphins appear to be restricted to waters relatively close to shore, preferring shallower and warmer water than the short-beaked common dolphin (Perrin 2002). However, habitat partitioning among the two species is not clear-cut and is not typical for areas outside California and Baja California (Pinela et al. 2011). In fact, mixed aggregations of short- and long-beaked common dolphins have been reported within the SCB (G. Campbell and

T. Jefferson, pers. comm., 2011), and considerable geographical overlap has been observed in the SCB (Smultea et al. 2009, 2010, 2011a).

Common dolphins are typically sighted in schools of hundreds to over 1,000 individuals (Evans 1994; Jefferson et al. 2008). Nineteen species of fish and two species of cephalopods have been found within the stomachs of *Delphinus* from California waters, most of which are associated with the vertically migrating deep-scattering layer (Evans 1994). Off San Clemente Island, a distinct diurnal movement pattern has been recently reported, with common dolphins moving offshore into deeper waters in the late afternoon and evening, and returning inshore at dawn (Henderson 2010). This movement combined with the low rate of observed daytime foraging, analyses of vocalizations, and stomach content analyses suggest that common dolphins in this region are primarily engaged in night-time feeding (Henderson 2010).

We observed a total of 307 common dolphin groups consisting of an estimated 79,254 individuals (Table 2). Individuals were seen during all survey months from May-November. Consistent with past SCB studies, common dolphin sighting rates were relatively high in summer (11.4 groups/1,000 km) and fall (13.7 groups/1,000 km) (Figure 2). Sighting rate increased across the day from 8.8 in the morning to 15.9 groups/1,000 km in the late afternoon. Overall, mean group size was 258 ± 39.7 individuals. Although mean group size was higher in the morning (302 ± 119.0) vs. mid-afternoon (251 ± 50.4) and late afternoon (240 ± 64.6), this difference was not significant given the high degree of variability in group size. There was also no significant change observed in group size by season. We observed a mean maximum dispersal between individual common dolphins within subgroups of 5 ± 0.7 BL, with no significant changes by time of day or season.

Common dolphins were predominantly (37% of 110 groups) observed to "surface-active mill" followed by travel (34%) and surface-active travel (21%) based on initially observed behavior state. This species was the most surface-active of all marine mammal species observed, with 58% of all groups observed in a surface-active behavior state. Overall, mean heading of common dolphins groups was southerly (188º ± 15.8) as represented primarily by summer observations; no significant differences were found in headings by survey period or time of day (Figure 6). The latter result does not support observations reported by Henderson (2010) suggesting that common dolphins headed predominantly westward in the late afternoon and evening and predominantly eastward at dawn (based on 61 common dolphin groups observed on 97 days from a stationary vessel near San Clemente Island in 2006-2008).

In summary, common dolphins were observed in very social, large, relatively consistent group sizes of around 250 - 300 animals, with a trend for larger group sizes in fall vs. spring/summer. Despite large group aggregations, individuals appeared to be consistently very cohesive within subgroups based on a relatively small mean maximum dispersal distance and associated low variability around this distance. Overall, common dolphins were more likely to be headed in a southerly direction, although there were no significant diurnal differences in headings unlike reported for this species near San Clemente Island.

<u>California sea lion *Zalophus californianus*</u>

The California sea lion ranges along the west coast of Mexico to southern British Columbia, from about 19 degrees N latitude northward to 50 degrees N latitude. This is the most commonly observed pinniped in the SCB although its relative abundance is related to time of year. During the breeding season (May-July), nearly the entire population occurs south of 34 degrees N latitude. Breeding California sea lions occur in large numbers at and near colonies at the southern California Channel Islands (principally San Nicolas and San Miguel islands) from late May through August (Stewart et al. 1993). Most rookery sites in the Channel Islands are used as haul-out areas during the non-breeding season (Stewart and Yochem 2000). Sea lions seen near the mainland coast in southern California may be from the colony at the Coronado Islands in northern Baja California or perhaps even colonies farther south. Non-breeding sea lions from U.S. colonies occur farther north along the California coast throughout summer, and may remain there or move even farther north, during fall and winter. California sea lions are least abundant in the SCB during fall and winter when adult and subabdult males, many juveniles, and some adult females forage off northern and central California, Oregon, Washington, and British Columbia (Stewart et al. 1993). Adult females and pups generally remain year-round south of Monterey Bay, California, feeding in coastal waters in the summer and moving offshore in the winter (Melin and DeLong 2000; Melin et al. 2008).

The California sea lion is a coastal animal rarely venturing seaward off the continental slope (Antonelis and Fiscus 1980). Most individuals stay within 50 km of the rookery islands during the breeding season (Bonnell et al. 1978), primarily in productive upwelling areas around the islands or near Point Conception (Stewart et al. 1993). Bearzi et al. (2008) reported frequent sightings near canyons.

Life history of the California sea lion is strongly tied to the dynamics of the California Current System (CCS) (e.g., Block et al. 2010). During periods of strong negative upwelling in the CCS (e.g., El Nino-Southern Oscillation [ENSO] events), regional productivity declines and lactating female California sea lions travel farther from the colony, move farther offshore and dive deeper, presumably in response to movement of their prey deeper in the water column or to more productive areas (Melin et al. 2008). As a result, changes in distributions, pup production, female survivorship, and foraging behaviors of sea lions occur during El Niño years when there are substantial declines in their local abundance and distribution (e.g., Ono et al. 1987; DeLong et al. 1991). The unprecedented mortality of California sea lion pups born at San Miguel Island, California, and the record number of emaciated weaned pups that stranded along the central California coast in 2009 were associated with anomalous oceanographic conditions along the central California coast between May and August 2009 (Melin et al. 2010).

California sea lions are highly gregarious and often haul out in large numbers. Thus, most information on the occurrence and distribution of California sea lions in the SCB is based on observed densities at terrestrial haul -outs, though Bearzi et al. (2008) reported densities at sea nearshore off Santa Monica, California. General unquantified observations indicate that they are usually solitary while at sea, but tend to form large groups near food-rich areas (Antonelis and Fiscus 1980). California sea lions often “raft” at the water surface alone or in groups. They engage in cooperative foraging behavior with common dolphins (*Delphinus* spp.) along the ridges and canyons of the SCB per vessel-based observations of 140 sightings made at sea in Santa Monica Bay from 1997- 2001 (Bearzi 2006).

When in the SCB, this species forages mostly at depths of 150 to 300 feet, primarily in offshore upwelling areas, though they may also occasionally forage on demersal prey in nearshore kelp beds. During the breeding season, females are primarily coastal foragers and shallow divers

(Melin and DeLong 2000). During the non-breeding season, Melin and DeLong (2000) reported that tagged females forage over the slope or offshore.

The California sea lion diet is temporally dynamic, with animals feeding on seasonally abundant schooling or aggregating prey. Northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), Pacific whiting (*Merluccius productus*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), shortbelly rockfish (*Sebastes jordani*), and market squid (*Loligo opalescens*) are their main prey in southern California (Lowry and Carretta 1999; Lowry et al. 1990, 1991). Diet of sea lions becomes more variable during El Niño oceanographic events due to decreased abundance and availability of their preferred prey. Migrating sea lions, especially subadult and adult males, may forage closer to the mainland coast, often associating with recreational and commercial fishing vessels, feeding on fish used for chum and depredating (i.e., taking) the fish (i.e., yellowtail, barracuda, or bonita) that have been caught (Hanan et al. 1989).

We observed a total of 298 California sea lion groups of an estimated 857 individuals (Table 2). Consistent with past SCB studies, they were seen during all survey months from May-November with highest at-sea sighting rates in fall (14.82 groups/1,000 km) vs. summer (9.37 groups/1,000 km) (Figure 8). Morning and mid-afternoon sighting rates (13.4 and 13.6 groups/1,000 km, respectively) were nearly double those observed in the late afternoon (6.9 groups/1,000 km) (Figure 8). This pattern could indicate that California sea lions tended to haul-out more in late afternoon and were thus not seen during line-transect surveys.

Consistent with other reports, California sea lions tended to occur alone or in small groups while at sea, with little variation in group size. Overall, mean group size was 3 ± 0.7 individuals. Although mean group size was somewhat lower in summer (2 ± 0.7) vs. fall (3 ± 0.9), this difference was not significant (X^2=1.42, df=1, p=0.23). Mean maximum dispersal distance between individuals within subgroups was 6 ± 3.8 BL, indicating that synchronized groups tended to remain close to one another while at sea, presumably socializing. Dispersal distance was not found to differ significantly by time of day or season.

California sea lions were most frequently (60% of 99 groups) observed "traveling" (swimming) in point-to-point movement based on initially observed behavior state, followed by milling (33%), with very little surface-active behavior seen (8%). Overall, mean heading of California sea lion groups was to the SSW (210º ± 25.3) as represented primarily by fall observations; no significant differences were found in headings by survey period or time of day (Figure 12).

Risso's dolphin *Grampus griseus*

Risso's dolphins in the SCB belong to the California/Oregon/Washington stock inhabiting shelf, slope and offshore waters within the SCB, and ranging into more northern slope and offshore waters into Washington (Carretta et al. 2011). Historical, year-round aerial surveys in the region indicate that this stock occurs most commonly off California during the colder water months then appears to generally shift northward primarily into Oregon and Washington waters during the warmer-water periods in late spring and summer (Green et al. 1992; Carretta et al. 2011). However, the abundance and distribution of this species appears vary with changes in seasonal and inter-annual oceanographic conditions (Forney and Barlow 1998).

Based on surveys between 1991 and 2008, Barlow and Forney (2007) and Barlow (2010) report abundance estimates ranging from approximately 4,000 to 11,000 animals in California waters, with no apparent consistent trend in abundance. However, In the SCB, Risso's dolphins appear to have been increasing in abundance over the last few decades (e.g., Leatherwood et al. 1980; Shane 1995; Forney et al. 1995; Carretta et al. 2000; Smultea et al. 2009, 2010, 2011 a,b; Jefferson et al. 2011), before which they were considered relatively rare. Their influx was correlated with the apparent near abandonment of SCB waters by short-finned pilot whales in the early 1980s in association with a severe ENSO and drop in squid abundance (Barlow 1995; Shane 1995). Within the SCB, Risso's dolphins have been consistently associated with shelf-edge habitats and other steep underwater topographical features from the mainland coast to waters west of San Clemete Island (SCI) (Carretta et al. 2000; Carretta et al. 2011; Forney and Barlow 1998; Smultea et al. 2009, 2010, 2011 a,b), usually over water depths of 400-1000 m (Baird 2008).

The social, feeding, and diving behavior of Risso's dolphins are little described. Reported typical group sizes for Risso's dolphins off California range from about 10-50 individuals (Forney and Barlow 1993, Baird 2008). In areas outside the SCB, stable groups of adults have been reported within larger aggregations. Limited data from a school killed in a drive fishery in Japan, it has been hypothesized that mature males travel between groups.

We observed 148 Risso's dolphin groups comprised of an estimated 2473 individuals during SCB aerial surveys from 2008-2010 (Table 2). Consistent with past SCB studies, Risso's dolphins were seen during all survey months from May-November. However, sighting rates (corrected for effort) were much higher in summer (9.96 groups/1000 km) vs. fall (2.33 groups/1000 km) (Figure 14). In contrast, Carretta et al. (2000) reported that Risso's dolphins were more abundant in fall than in summer. Risso's dolphin sighting rates tended to increase across the day: 4.46 groups/1,000 km in the morning, 6.31 groups/1,000 km in the mid-afternoon and 7.26 groups/1,000 km in the late afternoon (Figure 14). This could suggest diurnal inshore-offshore movement of the species such that they may have been farther offshore or out of our SCB study area in the morning periods. Overall, mean group size was 19 ± 3.3 individuals (n = 148) and was significantly lower in summer (16 ± 3.0, n = 118) than in fall (29 ± 10.3, n = 30) (Kruskal: X^2= 6.27, df=1, p=0.012). There was no significant difference in group size by time of day (Kruskal: X^2= 0.53, df=2, p=0.766). Overall, mean maximum dispersal distance between individuals was 6 ± 1.4 BL, n = 23). This dispersal distance decreased significantly across the day, with the largest maximum dispersal in the morning (10 ± 4.8 BL, n = 23) and the shortest maximum inter-individual distance during late afternoon (3 ± 0.77, n = 31) (Kruskal: X^2= 20.148, df=2, p<0.000).

Risso's dolphins were nearly always (80% of 114 groups) observed "traveling" in slow, point-to-point movement based on initially observed behavior state. Surface-active behavior was rarely observed (3% or 4 of 114 groups), unlike for common dolphins (Table 2). Similarly, Shane (1995) reported that 84% of 234 records of Risso's dolphin behavior off Santa Catalina Island consisted of a travel behavioral state (note however, that the latter data includes multiple recordings from the same group(s) followed from a small research vessel using instantaneous samples collected at 5-min intervals; the total number of separate groups was not indicated). Similarly, in Monterey Bay, California, Kruse (1989) reported that traveling was the most common behavioral state recorded for Risso's dolphins. Shane (1995) found that Risso's dolphins were engaged in feeding in only 1% of the 234 samples (diving repeatedly in the same location and surfacing facing in different directions); she hypothesized that feeding was rarely observed among Risso's dolphins because they were believed to feed primarily nocturnally, supported by tagging data from a single Risso's dolphin reported by Mate (1989).

However, the observed predominant slow travel behavior appears to contrast unquantified behavior observed among Risso's dolphins off Monterey Bay approximately 837 km north of the SCB (K. Forney and T. Jefferson, pers. comm., 2011). The latter dolphins are frequently surface-active such as porpoising, leaping, breaching, etc. Another interesting contrast for our recent Risso's dolphins observations compared to studies in the region from the 1980s and from Monterey Bay is that we rarely observed Risso's associated with other marine mammal species. Of our total 148 Risso's dolphin sightings, only 5 were associated with another species, most of which were California sea lions and common dolphins (3% of Risso's mixed species sightings); only 0.6% were with bottlenose dolphins. In contrast, Shane (1994) reported that Risso's commonly associated with bottlenose dolphins near Santa Catalina Island during 1983-1991. In Monterey Bay, Risso's dolphins appear to also associate more frequently with other marine mammals species than we observed in the SCB. Kruse (1989) reported that Risso's dolphins sightings from 1985 to 1987 were associated with another species, primarily northern right whale dolphins but also bottlenose dolphins. Extensive aerial surveys of the SCB conducted by the SWFSC during the 1980s and 1990s also may have had higher rates of mixed species associations for Risso's dolphins, particularly with bottlenose dolphins (Karin Forney, pers. comm., 2011). Interestingly, Risso's dolphins were associated with bottlenose dolphins during 1 of 66 Risso's sightings during approximately 24,854 km of aerial survey effort off the SCB from February-May 2011 (HDR, unpublished data).

Overall, mean heading of Risso's dolphin groups was to the SSW (195º ± 19.5) as represented primarily by summer observations. A slight temporal trend suggested more easterly movement in the morning vs. more westerly in the afternoon, but this difference was not significant (Figure 18). There were also no significant differences found in headings by survey period (Figure 18). Focal follows of this species for periods of up to one hour indicate that SCB Risso's dolphins are observable at or near the surface for extended periods of time engaged predominantly in very slow, synchronized travel in tight formations (SES, unpublished data). These observations suggest that during daylight periods, Risso's dolphins appear to rest/socialize, as suggested previously by Shane (1995) for Risso's dolphins observed near Santa Catalina Island in the 1980s during winter. The predominance of DSL prey species in stomach content analyses along with the diurnal resting behavior indicates that SCB Risso's dolphins are nocturnal feeders. Similar behavioral patterns have been documented for nocturnal-feeding/diurnal-resting Hawaiian spinner dolphins (e.g., Norris et al. 1994).

In summary, Risso's dolphins were most common during late spring/early summer, in contrast to SCB studies in 1998-1999 when they were most common during fall and winter (Carretta et al. 2000). Group size was consistently relatively small (about 20-30 individuals) compared to common dolphins, with largest group sizes during the fall cool-water season and during the morning. Group cohesiveness tended to be consistently tight based on dispersal distance of individuals within subgroups, with closer inter-individual spacing during the afternoon than the morning. Risso's dolphins predominantly traveled slowly and surface-active behavior was rarely observed, in contrast to behavior reported for this species to the north in Monterey Bay. Risso's dolphins were also less frequently associated with other species than reported for Monterey Bay. Differences in the behavior of Risso's dolphins in the SCB vs. farther north may be related to differences in prey abundance, distribution and behavior. Further examination of oceanographic and prey influences may reveal reasons for the observed geographical differences in behavior of Risso's dolphins.

Fin whale *Balaenoptera physalus*

Fin whales in the SCB belong to the California/Oregon/Washington stock within the eastern North Pacific population that ranges from Alaska to Mexico (Carretta et al. 2011). Historical surveys indicate that these whales occur year-round in southern/central California, with peak feeding numbers in summer and fall (Dohl et al. 1981; Forney et al. 1995; Barlow 1997; Carretta et al. 2000). They also feed during summer in Oregon (Green et al. 1992; McDonald 1994), and during summer/autumn in the Shelikof Strait/Gulf of Alaska (Brueggeman et al. 1990). Vocalizing fin whales have been recorded year-round off northern California, Oregon and Washington, principally between September and February (Moore et al. 1998). However, visually observed fin whale numbers appear to decline in winter/spring off California (Dohl et al. 1981; Forney et al. 1995; Smultea et al. 2009, 2010; Jefferson et al. 2011) and Oregon (Green et al. 1992), suggesting that they seasonally move outside these areas (Carretta et al. 2011). There are no reliable estimates on the current and historical abundance of fin whales in the entire northeast Pacific (NOAA 2011). The last estimate of 3,279 fin whales for the California/Oregon/Washington stock was based on ship surveys conducted in summer/autumn of 1996 (Barlow and Taylor 2001) and 2001 (Barlow 2003). Jefferson et al. (2011) recently estimated that 1.22 animals/100 km^2 inhabit the SCB during summer and fall using data from the same eight aerial surveys reported herein from 2008-2010.

Fin whales are typically associated with continental shelf waters (Jefferson et al. 2008). Within the SCB, recent studies indicate that fin whales concentrate primarily in waters west of SCI within the Navy's Southern California Anti-Submarine Warfare Range (SOAR), particularly along steep underwater ridges (Carretta et al. 2000; Smultea et al. 2009, 2010; Jefferson et al. 2011; Schorr et al. 2010). In particular, during June, we have commonly observed fin whales across San Nicolas Basin/SOAR between SCI and Tanner Bank (Smultea et al. 2009). However, they are also commonly found feeding within 10 km of San Diego, oftentimes with blue whales (Smultea et al. 2009, 2010, 2011b). Satellite-tagging of a few fin whales indicates that they travel between California, Oregon and Washington over periods of several days (Schorr et al. 2010). Schorr et al. (2010) suggested that fin whales may move relatively quickly between likely feeding areas, but remain more localized within those feeding areas for periods of time.

During the summer, fin whales lunge feed on krill, small schooling fish (e.g., herring, capelin, and sand lance), and squid but fast during the winter after migrating to warmer waters (NOAA 2011). We have observed and documented (with video) fin whales lunge feeding on swarms of red krill with frequent reddish –colored defecations within the SCB, including apparent inter-specific feeding competition with blue whales (SES and HDR unpublished data, Smultea et al. 2011b).

Specific breeding and calving areas of fin whales are unknown, but whaling data indicate that this activity occurs during mid-winter in more southern tropical and sub-tropical waters (Jefferson et al. 2008; NOAA 2011). Accordingly, the social and mating systems of fin whales are not well described or quantified. Available data indicate that long-term associations between individuals are rare, similar to most other baleen whales (NOAA 2011). Schorr et al. (2010) reported that fin whales off California to Washington are often observed in loose large aggregations; however, data from a small number of tagged individuals indicate that associations are ephemeral in nature. In the SCB, we have observed and documented (with video) socializing and touching among fin whales in what appear to be courting behaviors based on similarity with courting behaviors reported for humpback, gray, and bowhead whales (SES and HDR, unpublished data). We have also observed fin whale calves in the SCB (Smultea et al. 2009).

On the North Atlantic feeding grounds, fin whales typically occur in social groups of 2-7 individuals where they are frequently seen feeding in large groups or aggregations in association with humpback whales, minke whales, and Atlantic white-sided dolphins (Jefferson et al. 2008). In the SCB, we have commonly seen them interspersed with aggregations of blue whales but only rarely with other marine mammal species (SES and HDR unpublished data). One focal follow involved a mother-calf fin whale following and interacting (e.g., rolling, touching) with over 1,000 northern right whale dolphins documented for over 40 min with video in June 2009. The mother-calf pair remained at the tail end of the dolphin group. The dolphins appeared to interact with the fin whale mother and calf by swimming between and around them, while the fin calf often rolled on its mother's back/rostrum, meandering while slowly traveling.

During our 2008-2010 SCB aerial surveys, we observed a total of 51 fin whale groups comprised of an estimated 86 individuals (Table 2). Individuals were seen during all survey months with the highest sighting rate in May-June (Figure 20). The May-June sighting rate was 2-3 times higher than the July-September and October-November sightings rates; this difference was significant (X^2=13.73, df=2, p=0.001). Carretta et al. (2000) also reported seeing the fin whale year-round in our study area in 1998-1999, with highest abundance during warm-water (May-October) vs. cold-water (November-April) seasons. We did not find any significant diurnal differences in sighting rates (X^2=1.30, df=2, p=0.523).

Similar to blue whales, fin whales were nearly always (92% of 51 groups) observed "traveling", followed by milling (4%) and surface-active travel (4%). Like blue whales, this traveling probably involved feeding based on frequent reddish defecations and occasional lunge-feeding seen during the longer focal follow behavioral sessions (SES/HDR unpublished data). Overall, mean heading of fin whale groups was to the SSW (189 º ± 33) as represented primarily (36 of 51 groups) by summer observations. No significant differences were found in headings by survey period or time of day (Figure 24). Fin whales were headed more southwesterly in the mornings (212º ± 71.0) and more southeasterly in the afternoons (173º ± 43.9) though this trend was not significant (Kruskal:X^2=0.009, df=1, p=0.922). There were also no significant trends in heading by season (Kruskal: X2=0.550, df=1, p=0.458). Rather, headings were variable. Surprisingly few individuals headed south or north during the expected fall migration period (Figure 24).

Overall, mean group size of fin whales was 2 ± 0.2 individuals (n=51). This mean was nearly three times higher than that reported by Carretta et al. (2000) for fin whales in 1998-99 in the same region and season (warm-water season)(mean 1.3, n = 15). We observed smaller fin whale group sizes during late afternoon (mean 1 ± 0.3) than earlier in the day (2 ± 0.3), though this difference was not significant (Kruskal: X^2=5.308, df=2, p=0.070). No significant difference was found for group size in fall (mean 2 ± 0.6) vs. summer (mean 2 ± 0.2) (Kruskal: X^2=2.236, df=1, p=0.135). Carretta et al. (2000) reported a smaller mean group size of 1.0 fin whales (n=6) during the cool-water season; we did not survey the cool-water season. Tershy (1992) reported a median group size of 2.0 among traveling fin whales (n=197 sightings) in the central Gulf of California during year-round observations.

Mean maximum dispersal between individual fin whales within a group was 8 ± 4.6 BL, considerably less than the distance between blue whales in synchronized groups (16 ± 8.7 BL) (Table 2). Dispersal distance ranged from ~0.5 to 50 BL among fin whale groups, although socializing involving individuals touching was never observed during the May-November study period. Fin whales were occasionally (n = 2 events) seen in loose feeding aggregations with blue whales. In one focal behavioral session, video was taken of two fin whales suddenly increasing speed and turning sharply in front of several blue whales with one of the fin whales then gulping a reddish prey concentration of presumed krill.

Blue whale *Balaenoptera musculus*

Blues whales in the SCB belong to the Eastern North Pacific stock ranging from Alaska to the Costa Rica Dome. Southern and central California coastal waters are important feeding areas for this population in the summer and fall where their numbers appear to have increased from 1979-1996 (Carretta et al. 2011). Since 1996, blue whale numbers have fluctuated and declined off California, attributed to changes in the portion of the population feeding there in summer and fall (Calambokidis et al. 2009). In winter and spring, these whales migrate to biologically productive waters off Baja California, the Gulf of California, and the Costa Rica Dome, where at least small numbers are seen year-round (Reilly and Thayer 1990, Carretta et al. 2011). The population is believed to feed throughout the year. Breeding and calving areas are unknown but whaling data indicate this activity occurs during winter in more southern tropical and sub-tropical waters (Jefferson et al. 2008).

A total of 49 blue whale sightings of 84 individuals occurred (Table 2). Consistent with past DCB studies, blue whale sighting rates were highest in summer/fall. Individuals were seen during all survey months from May-November. However, sighting rates were significantly higher in summer (n=48 groups) vs. fall (1 group) (X^2=11.52, df = 3, p=0.001); (Figure 26). Overall, mean group size was 2 ± 0.4 individuals and was smaller in May-June (1.X whale per sighting) vs. July-December (2.X whales per sighting), although the difference was not significant (Kruskal: X2=0.859, df=1, p=0.354). Blue whale sighting rates were significantly lower in the morning than during the afternoon (X^2=9.94, p=0.007) (Figure 26).

Blue whales were nearly always (85% of 49 groups) observed "traveling" in point-to-point movement based on initially observed behavior (necessarily limited to a period within a surfacing bout), followed by milling (11%) and surface-active travel (4%) (Table 2). Overall, mean heading of blue whale groups was to the SSW (203º ± 35) as represented primarily by summer observations; no significant differences were found in headings by survey period or time of day (Figure 28). Travel also involved feeding on some occasions based on data from extended focal follows (SES/HDR unpublished data). Similar to fin whales, heading among blue whales was nearly always consistent and synchronized between individuals within a surfacing bout, but often changed between dives; the latter behavior combined with occasionally observed lunge feeding, reddish-colored defecation and swarms (presumed to be krill) indicate that blue whales are feeding in concentrated areas (SES/HDR unpublished data). Mean maximum dispersal between individuals was 16 ± 8.7 BL. We are not aware of other publications that systematically reported dispersal distances within groups of blue whales or any other baleen whales except mother-calf southern right whales (e.g., Tabor and Thomas 1982).

Common Bottlenose Dolphin *Tursiops truncatus*

Bottlenose dolphin distribution off California extends from at least Ensenada, Baja California, Mexico to as far north as 41 degrees N off California, ranging into Oregon and Washington waters during warm-water periods (Carretta et al. 2011). The bottlenose dolphin is a year-round resident to SCB waters. Three ecotypes are considered to occur in the SCB: coastal, island-associated, and oceanic (K. Forney, NMFS-SWFSC pers. comm. in DoN 2008).

Detailed long-term studies on bottlenose dolphins in the SCB have focused primarily on coastal communities along the San Diego coastline (within 1 km of coastline; Defran and Weller 1999). Pacific Coast bottlenose dolphins travel rapidly and extensively along the coastline in search of optimal feeding opportunities (e.g., Defran et al. 1999; Hwang 2011). Oceanographic events influence distribution; for example, there has been a change in residency patterns along Southern California and a northward range extension into central California after the 1982-83 El Niño (Hanson and Defran 1993; Wells et al. 1990). Since the 1982-83 El Niño, which increased water temperatures off California, bottlenose dolphins are sighted regularly in central California, as far north as San Francisco. Hwang (2011) suggested that irregular upwelling patterns off California might explain the apparent lack of a pattern in dolphin movements. In some parts of the SCB, such as Santa Monica Bay, the species occasionally aggregates offshore near areas of bottom relief, such as submarine canyons and escarpments (Bearzi 2005).

Bottlenose dolphins occur year-round offshore around the islands of San Clemente, Santa Catalina, and San Nicolas (Bonnell and Dailey 1993; Shane 1994; Carretta et al. 2000). The relatively large population of bottlenose dolphins occurring offshore, as noted by Bonnell and Dailey (1993), appears to center around Santa Catalina Island during most of the year. Most bottlenose dolphins were sighted during the winter months in the area. During the summer; the island-associated population is widely distributed through the Channel Islands (Bonnell and Dailey 1993). NMFS-conducted marine mammal aerial surveys off San Clemente Island during 1998-1999 determined that bottlenose dolphins were seen year-round, but were also the least abundant of marine mammal species seen in the area (Carretta et al. 2000). The species is ubiquitous in the SCB, found in waters close to shore and further offshore, across a wide range of bottom depths (e.g., Shane 1994). Stomach content analyses indicate that a large percentage of SCB bottlenose dolphin prey includes surf perches (*Embiotocidae*) or croakers (*Scianidae*) (e.g., Hanson and Defran 1993; Bearzi 2005).

Past studies reported that bottlenose dolphins in waters off California often associate with Risso's dolphins, short-finned pilot whales, both common dolphin species, California sea lions, and gray whales (Norris and Prescott 1961; Shane 1994; Bearzi 2005). However, only one of the 25 bottlenose dolphin sightings reported herein were associated with other species.

A total of 25 bottlenose dolphin sightings of 553 individuals occurred (Table 2). Consistent with past SCB studies, individuals were seen during all survey months from May-November. Sighting rates were slightly higher in summer vs. fall (1.27 and 0.78 groups/1,000 km), respectively), but this difference was not significant (Figure 32). Overall, mean group size was 22 ± 7.6 individuals and was slightly higher in summer (24 ± 8.3) vs. fall (19 ± 14.7) although the difference was not significant. Mean maximum dispersal between individuals within a subgroup was 5 ± 2.8, with no significant diurnal or season trends noted based on the limited sample size.

Bottlenose dolphins were mostly observed "traveling" (54% and group n = 13) in point-to-point movement based on initially observed behavior, followed by surface-active travel (21%). Overall, mean heading of bottlenose dolphin groups was to the SSW (198º ± 19.5) as represented primarily by summer observations (Figure 36), with no significant diurnal or season trends based on the limited sample size.

Pacific white-sided dolphin *Lagenorhynchus obliquidens*

The Pacific white-sided dolphin is found only in temperate waters (Leatherwood et al. 1984). Surveys suggest a seasonal north-south distributional shift of the species in the eastern North Pacific as water temperatures change. There is a year-round occurrence of the white-sided dolphin in California waters (Bonnell and Dailey 1993). This species occurs primarily off California during the cool-water months, shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Barlow 1995; Forney et al. 1995). Soldevilla et al. (2010) documented a fall–winter peak in seasonal occurrence in the SCB based on acoustic detections. Dohl et al. (1981) also noted a winter-spring shift in the population from offshore to inshore waters in the SCB. The Pacific white-sided dolphin is most common in waters over the continental shelf and slope.

Bonnell and Dailey (1993) reviewed white-sided dolphin occurrence based on aerial surveys conducted by Dohl et al. (1981) in the late 1970s in the SCB. Peak numbers, exceeding 10,000 animals, occurred from about September through November. During these months, abundance increases first in northern waters of the SCB, especially in the western Santa Barbara Channel, over the San Miguel Island shelf, and along the Santa Rosa-San Nicolas Ridge. By October and November, these dolphins are fairly widespread in the area at slightly lower densities. By November, sightings in central and eastern waters of the SCB begin to increase, indicating a general dispersal southward. By winter, numbers sharply decline in California waters. During January in the SCB, sightings were recorded only in offshore waters over the Santa Rosa Cortes Ridge, suggesting that the reduction in numbers in the area results from an offshore shift in the species distribution. In the spring, distribution in the SCB shifts to inshore waters, where Pacific white-sided dolphin sightings are typically clustered within 30 km of shore. A few sightings were recorded close inshore through June and July.

Two forms of the white-sided dolphin – northern and southern – occur along the U.S. West Coast; both forms occur in the SCB (Carretta et al. 2011). The NMFS has noted that it is not currently possible to distinguish animals without genetic or morphometric analyses (Carretta et al. 2011). Two types of white-sided dolphins in the SCB are distinguished by vocalizations (see Soldevilla et al. 2011). Predictive models (using acoustic data from both types) for the white-sided dolphins in the SCB suggest that habitat features important to the species include both the importance of ecological succession between abiotic variables and dolphin occurrence, as well as an association with prey-aggregating features, such as fronts and eddies (Soldevilla et al. 2011).

Pacific white-sided dolphins in the eastern North Pacific feed primarily on epipelagic fishes and cephalopods (e.g., Schwartz et al. 1992; Heise 1997).

A total of 20 Pacific white-sided dolphin sightings of approximately 602 individuals occurred (Table 2). Given this relatively small sample size, interpretation of results is limited and potential diurnal and seasonal patterns cannot be assessed. However, as little is known about the behavioral ecology and social behavior of this species, results discussed herein contribute to a rare data base for the species. Consistent with past SCB studies, individuals were seen during all survey months from May-November, with sighting rates notably higher in fall vs. summer (0.25 vs. 1.32 groups/1,000 km, respectively (Figure 38). Overall, mean group size was 30 ± 20.6 individuals. Mean maximum dispersal between individuals within a subgroup was 10 ± 5.3 BL.

Pacific white-sided dolphins were primarily observed traveling (54% of 13 groups) based on initially observed behavior, followed by milling (26%), and surface-active travel or milling (27%). Overall, mean heading of Pacific white-sided dolphin groups was southerly (175º ± 63.5), with considerable variation (Figure 42).

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TABLES

Table 1. Summary of Aerial Surveys conducted during 2008 – 2010 in the SOCAL Complex Range.

	Survey								
	October	**November**	**June**	**July**	**November**	**May**	**July**	**September**	**Total**
Survey Dates	17-21 Oct 2008	15-18 Nov 2008	5-11 June 2009	20-29 July 2009	18-23 Nov 2009	13-18 May	27 July-3 Aug	23-28 Sept 2010	**8 surveys: May, June, July, Sept, Oct, Nov**
No. Days Flown	5	4	6	9	6	6	7	6	**49**
Major Training Exercise (MTE) Before, During or After Survey?	Before/During	After	After	After	During/After	During	During/After	During/After	**During, before or after**
Total Flight Hr (Wheels up/down)	28	21	30	34	28	29	18	19	**207**
Total Observation Effort (km) *(excl. poor weather, over land)*	4563 km	3838 km	6140 km	6500 km	4823 km	4891 km	3125 km	3918 km	**37,798**
	(2464 nm)	(2072 nm)	(3315 nm)	(3510 nm)	(2604 nm)	(2641 nm)	(1688 nm)	(2116 nm)	**20,410**
No. Navy-directed Survey Changes (appox)	9	7	12	10	3	1	0	0	**42**
No. Coastline Surveys for Strandings (San Clemente Isld)	0	2	1	0	1	1	0	0	**5**
No. Groups Seen	115	185	161	240	93	152	86	252	**1,284**
Estim. No. Individuals	12,587	5732	9489	22,719	12,826	5,453	11,090	37,874	**117,770**

	Survey								
	October	**November**	**June**	**July**	**November**	**May**	**July**	**September**	**Total**
Mean Group Size	109.4	31	58.9	94.7	137.9	35.9	131.3	150.3	**85.6**
No. Dead Sightings	0	3 *(2 CA sea lions, 1 blue whale)*	0	2 *(2 prob. CA sea lions)*	0	0	0	0	**5**
No. Species	9	9	11	10	10	9	5	9	**16***
No. Focal Groups Circled 5-9 min	22	20	24	37	14	10	6	6	**139**
No. Extended Focal Groups Circled >10 min	5	7	7	8	10	20	13	10	**83**
Longest Focal Follow Duration	29 min (*Fin whale*)	60 min (*Fin whale*)	48 min (*Fin whale*)	38 min (*Long-beaked common dolphin*)	40 min (*Killer whale*)	144 min (*Fin whale*)	59 min (*Blue whale*)	45 min (*Bryde's Whale*)	**144 min. total of longest focal**
No. Photos Taken	1050	1280	1099	2301	2203	1350	2900	741	**12,183**
Estimated Usable Video (min)	53	41	83	50	90	334	373	142.41	**1024**

*Note: Sixteen species were seen during the eight surveys. Not all species were seen during each survey.

Table 2. Overall Group Characteristics of Marine Mammals from 2008-2010 in the SOCAL Complex Range

Species	Scientific Name	No. of Groups	No. of Individuals	Mean of Greatest Group Size	Sighting Rate Indiv/1000 km	Mean Group Heading	Initial Group Behavior States	Mean of Greatest Group Dispersal
Common dolphin sp.	*Delphinus* sp.	307	79,254	258 ± 39.7	12	188º ± 15.8	37% SA Mill, 34% Travel, 21% SA travel, 8% Mill	5 ± 0.7
California sea lion	*Zalophus californianus*	298	857	6 ± 5.9	12	210º ± 25.3	60% Travel, 33% Mill, 4% SA mill, 4% SA travel	6 ± 3.8
Risso's dolphin	*Grampus griseus*	148	2743	37 ± 37.5	6	195º ± 19.5	80% Travel, 17% Mill, 2% SA Mill, 1% SA travel	6 ± 1.4
Fin whale	*Balaenoptera physalus*	51	86	3 ± 3.3	2.1	189º ± 33	92% Travel, 4% Mill, 4% SA travel	8 ± 4.6
Blue whale	*Balaenoptera musculus*	49	84	2 ± 0.4	2	203º ± 35	85% Travel, 11% Mill, 4% SA travel	16 ± 8.7
Bottlenose dolphin	*Tursiops truncatus*	25	553	22 ± 7.6	1	198º ± 52.1	54% Travel, 21% SA travel, 13% Mill, 13% SA mill	5 ± 2.8
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	20	602	30 ± 20.6	0.8	175º ± 63.4	47% Travel, 26% Mill, 16% SA travel, 11% SA Mill	10 ± 5.3
Humpback whale	*Megaptera novaeangliae*	5	9	2 ± 0.8	0.2	198º ± 52.1	100 % Travel	1 ± 0
Northern elephant seal	*Mirounga angustirostris*	5	24	8 ± 7.2	0.2	130 ± 184.1	75% Travel, 25% Mill	2 ± 1
Minke whale	*Balaenoptera acutorostrata*	4	6	2 ± 1.0	0.2	31º ± 60.3	75% Travel, 25% SA travel	10 ± 0

Species	Scientific Name	No. of Groups	No. of Individuals	Mean of Greatest Group Size	Sighting Rate Indiv/1000 km	Mean Group Heading	Initial Group Behavior States	Mean of Greatest Group Dispersal
Cuvier's beaked whale	*Ziphius cavirostris*	4	12	3 ± 1.9	0.2	145º ± 132.9	100 % Travel	2 ± 0.7
Northern right whale dolphin	*Lissodelphis borealis*	3	1,200	400 ± 312.4	0.1	223º ± 136.9	100% SA Travel	8 ± 4.1
Bryde's whale	*Balaenoptera edeni/brydei*	2	2	1 ± 0	0.1	145º ± 112.9	100 % Travel	0
Killer whale	*Orcinus orca*	2	67	34 ± 44	0.1	235º ± 194.3	100 % Travel	22 ± 36.9
Sei/Bryde's whale	*Balaenoptera borealis/edeni/brydei*	1	3	3 ± 0	0.04	120º ± 0	100 % Travel	8 ± 0
	Total:	**924**	**85,502**					

Table 3. Sighings of marine mammals from 2008-2010 in the SOCAL Complex Range in desecening order. Note: Sightings did not occur during January-March.

Species	Total Sightings	No. Summer Sightings	Summer Sighting Rate (Indiv/1000 km)	No. Fall Sightings	Fall Sighting Rate (Indiv/1000 km)	No. Apr-June Sightings	Apr-June Sighting Rate (Indiv/1000 km)	No. July-Sept Sightings	July-Sept Sighting Rate Indiv/1000 km	No. Oct-Dec Sightings	Oct-Dec Sighting Rate Indiv/1000 km
Common dolphin sp.	307	131	7	176	32	35	6	220	27	52	6
California sea lion	298	108	6	190	35	85	14	95	12	118	13
Risso's dolphin	148	118	6.1	30	1.1	75	12	49	6	24	2.7
Fin whale	51	36	1.8	17	2.9	25	4	10	1.2	16	1.8
Blue whale	49	48	2.5	1	0.2	12	1.9	36	4.4	1	0.1
Bottlenose dolphin	25	15	0.8	10	1.8	12	1.9	7	0.9	6	0.7
Pacific white-sided dolphin	20	3	0.2	17	3.1	2	0.3	1	0.1	17	1.9
Humpback whale	5	2	0.1	3	0.6	2	0.3	0	0	3	0.3
Northern elephant seal	5	1	0.1	6	0.7	1	0.2	3	0.4	1	0.1
Minke whale	4	2	0.1	2	0.4	1	0.2	2	0.2	1	0.1
Cuvier's beaked whale	4	1	0.1	3	0.6	0	0	2	0.2	2	0.2
Northern right whale dolphin	3	3	0	0	0	3	0.5	0	0	0	0
Bryde's whale	2	0	0	2	0.4	0	0	1	0	1	0.1
Killer whale	2	0	0	2	0.4	0	0	0	0	2	0.2
Sei/Bryde's whale	1	0	0	1	0.2	0	0	1	0.1	0	0
Total	**924**	**468**		**460**		**253**		**427**		**244**	

Table 4. Marine Mammal Sightings from 2008-2010 during each period of the day.

Species	Overall Number of Sightings	Sightings during the morning (6-12)	Morning Sighting Rate Indiv/1000 km	Sightings during the early afternoon (12-16)	Early Afternoon Sighting Rate Indiv/1000 km	Sightings during the late afternoon (16-20)	Late Afternoon Sighting Rate Indiv/1000 km
Common dolphin sp.	307	60	9	168	13	79	16
California sea lion	298	92	13	173	13	33	7
Risso's dolphin	148	31	4.5	81	6.3	36	7.3
Fin whale	51	15	2.2	29	2.3	7	1.4
Blue whale	49	4	0.6	31	2.4	14	2.8
Bottlenose dolphin	25	6	0.9	16	1.3	3	0.6
Pacific white-sided dolphin	20	3	0.4	16	1.3	1	0.2
Humpback whale	5	0	0	5	0.4	0	0
Northern elephant seal	5	1	0.1	3	0.2	1	0.2
Minke whale	4	2	0.3	2	0.2	0	0
Cuvier's beaked whale	4	2	0.3	2	0.2	0	0
Northern right whale dolphin	3	0	0	2	0.2	1	0.2
Bryde's whale	2	0	0	2	0.2	0	0
Killer whale	2	1	0.1	1	0.1	0	0
Sei/Bryde's whale	1	1	0.1	0	0	0	0
Total	**924**	**218**		**531**		**175**	

FIGURES

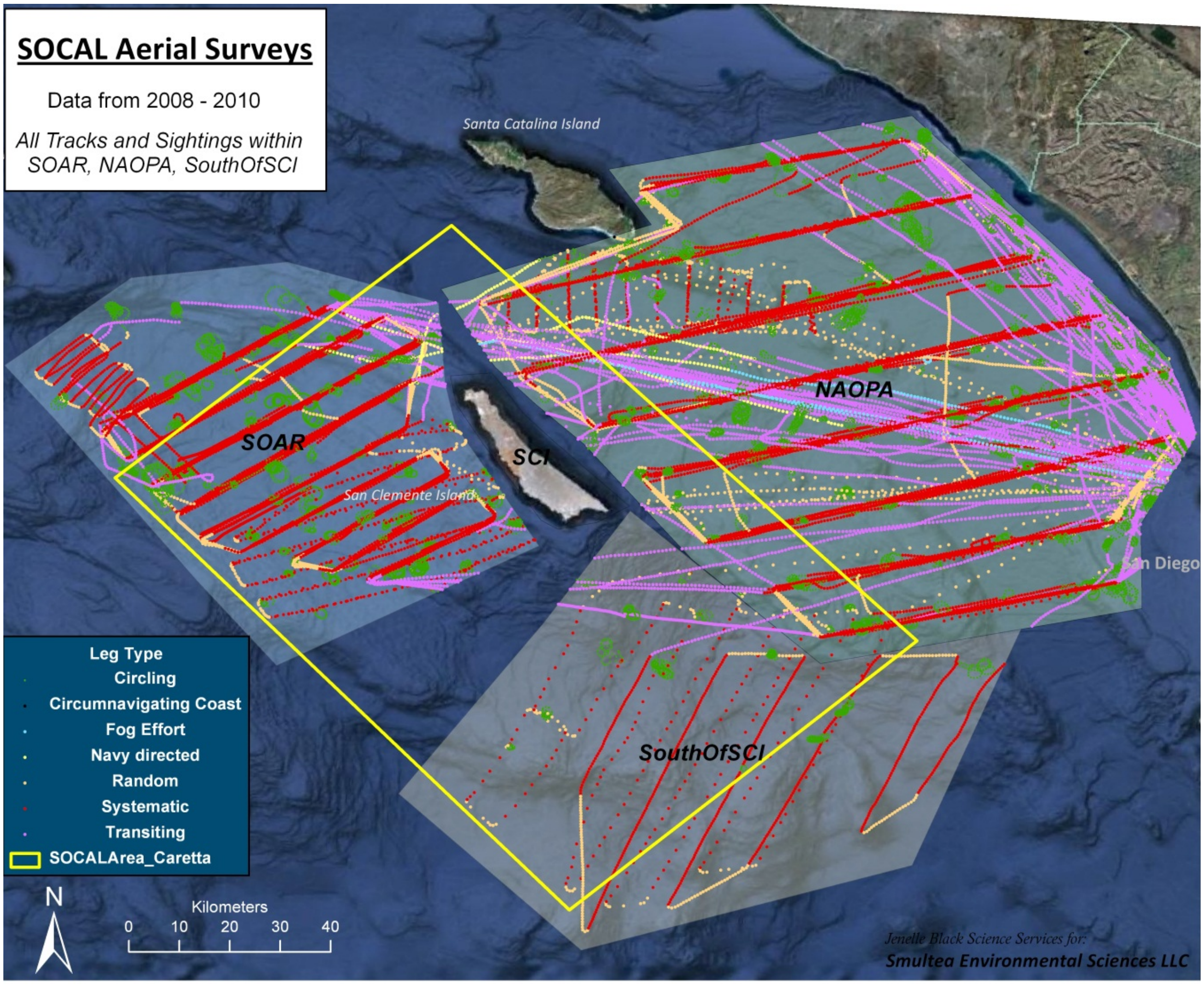

Figure 1. Survey tracks of all effort during 2008-2010 aerial surveys conducted during 2008-2010 in the SOCAL Complex Range.

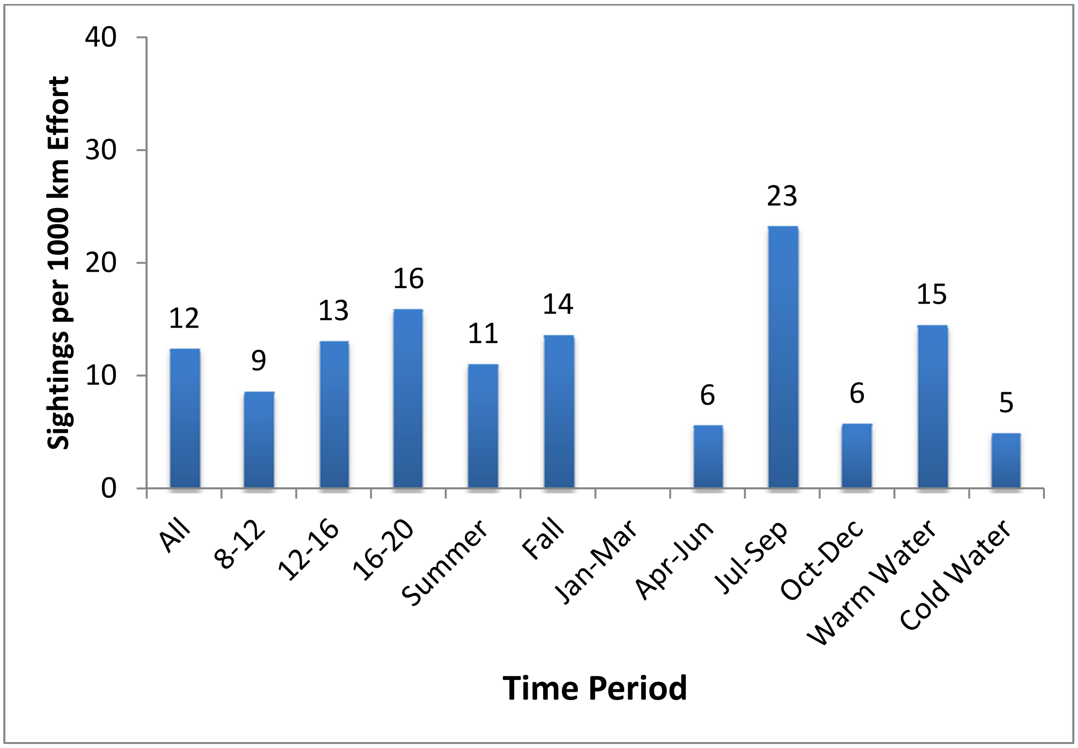

Figure 2. Common Dolphin Delphinus species sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

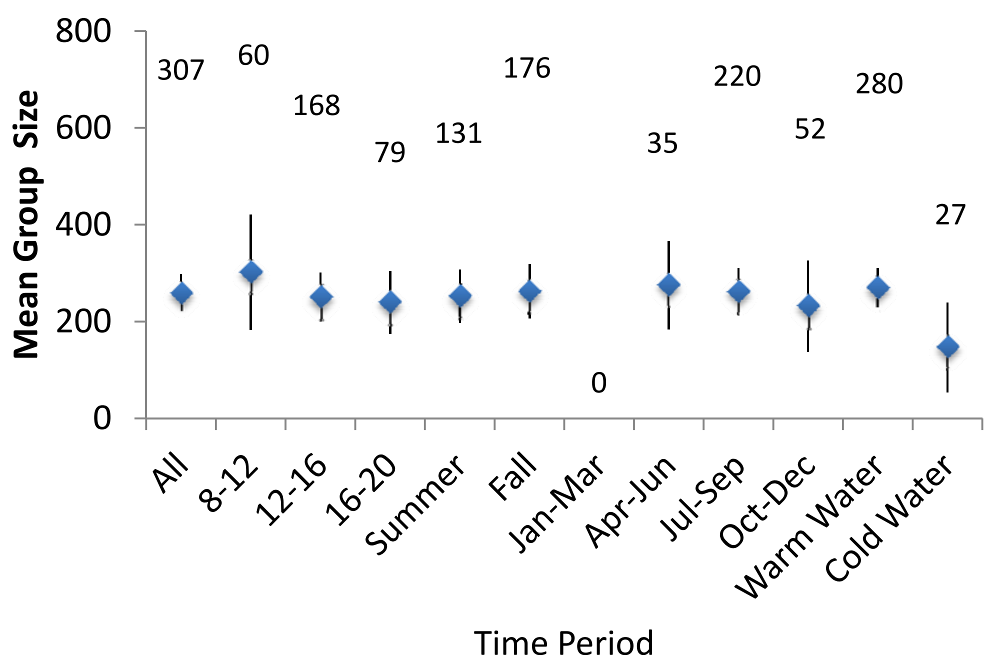

Figure 3. Common Dolphin Delphinus species mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

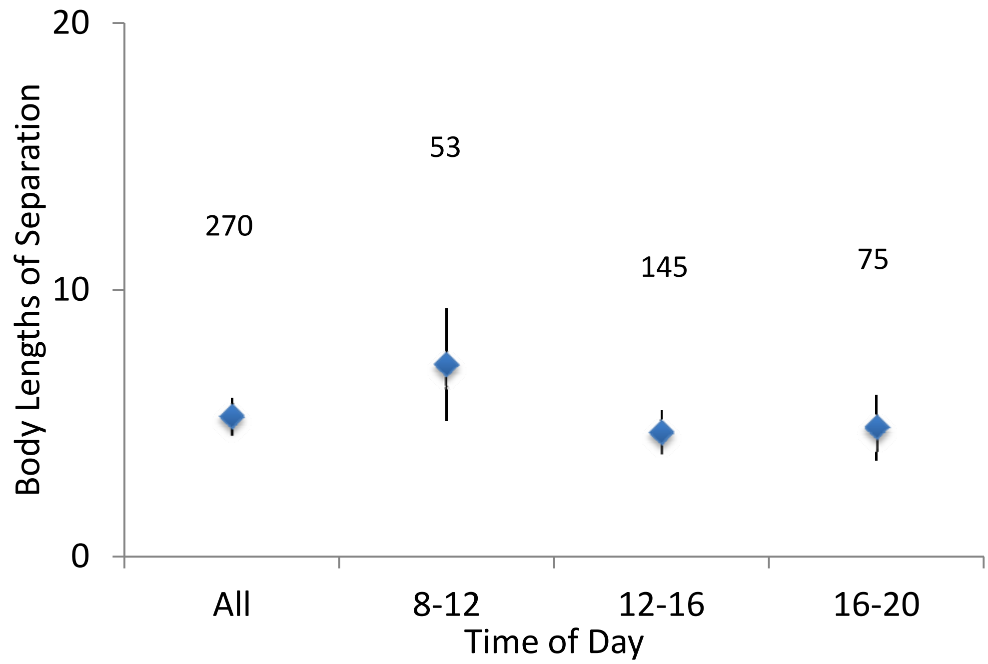

Figure 4. Common Dolphin Delphinus species mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

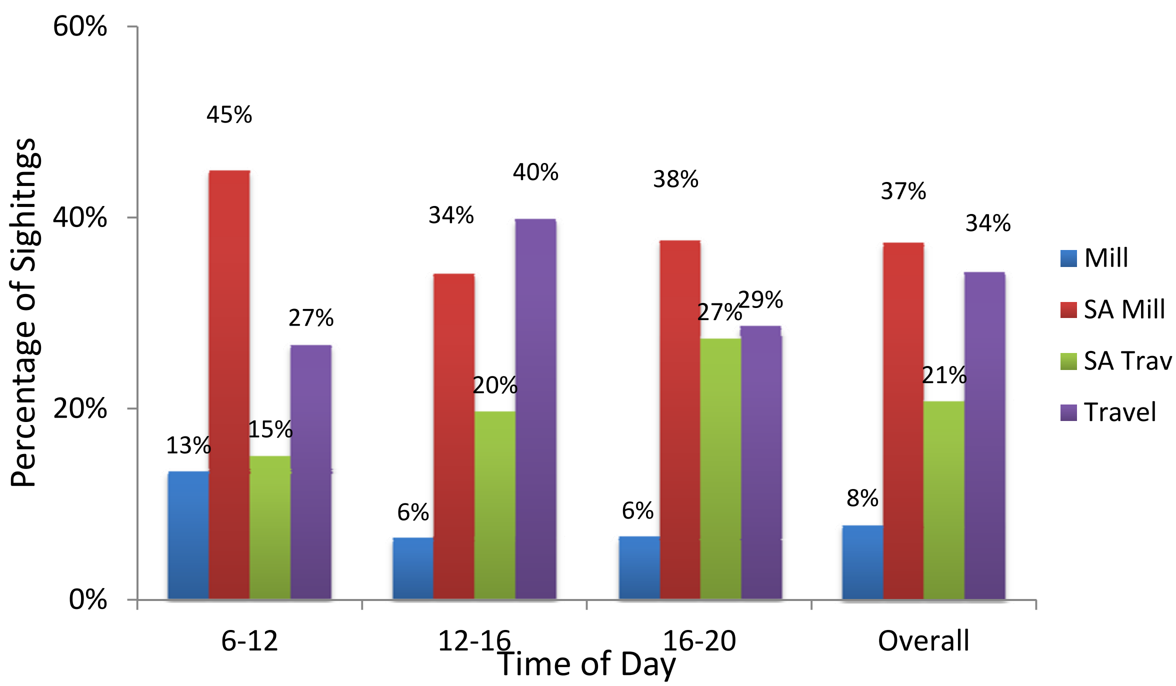

Figure 5. Common Dolphin Delphinus species initial behavior observed by time of day.

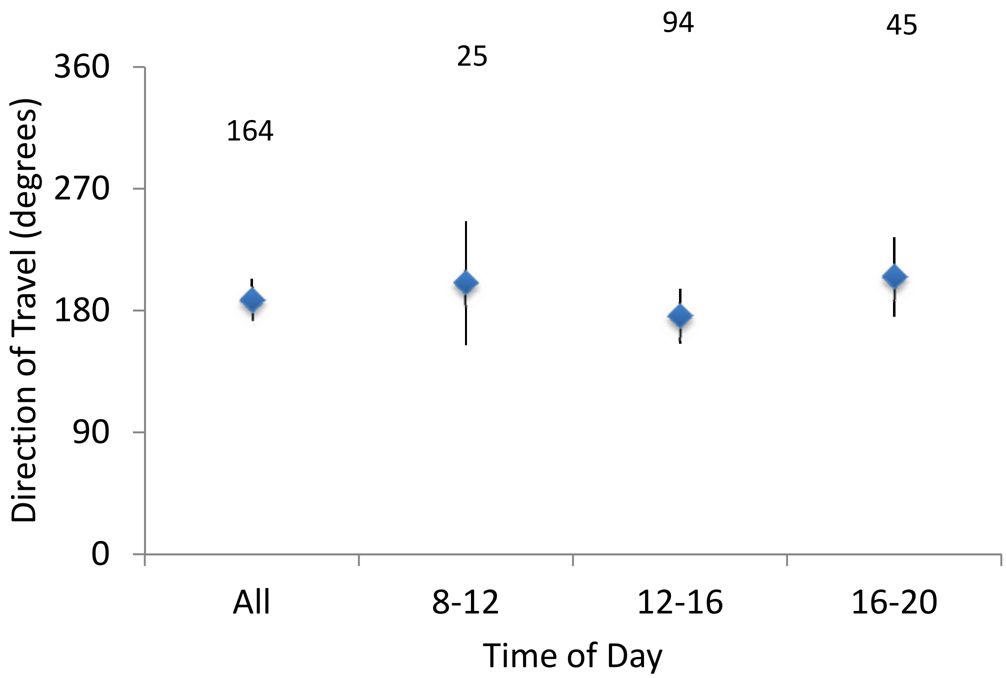

Figure 6. Common Dolphin Delphinus species mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

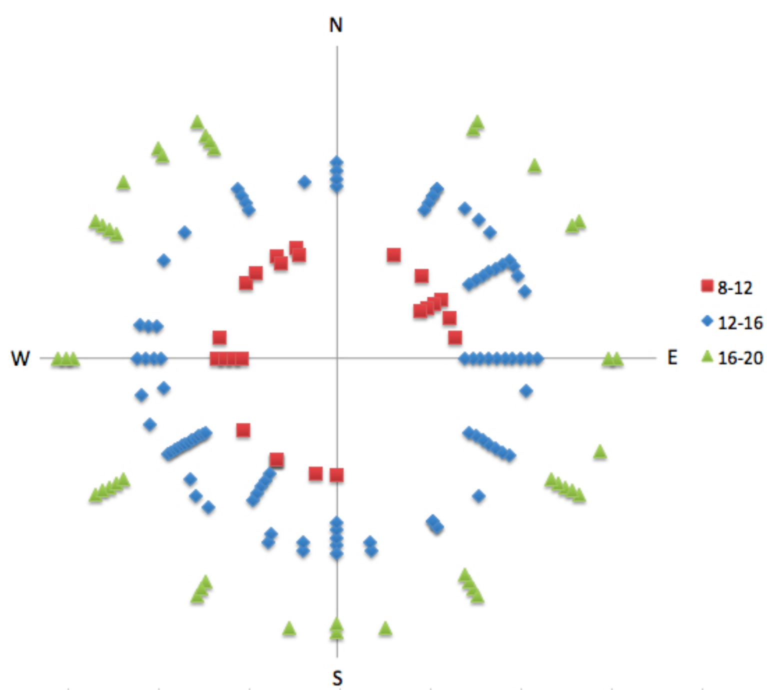

Figure 7. Common Dolphin Delphinus species mean group heading (degrees magnetic) by time of day.

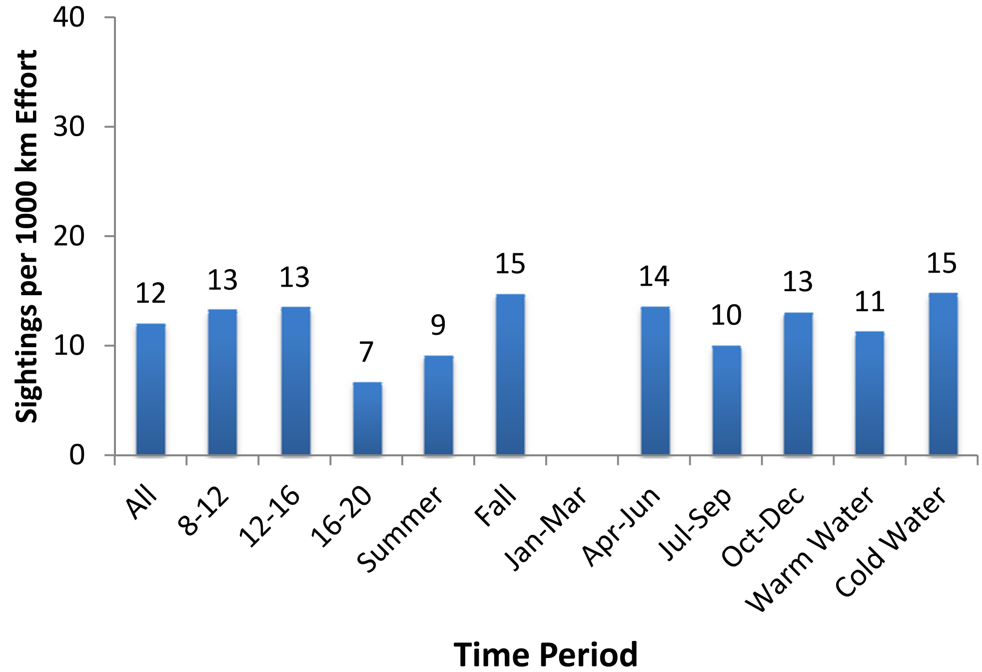

Figure 8. California Sea Lion Zalophus californianus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

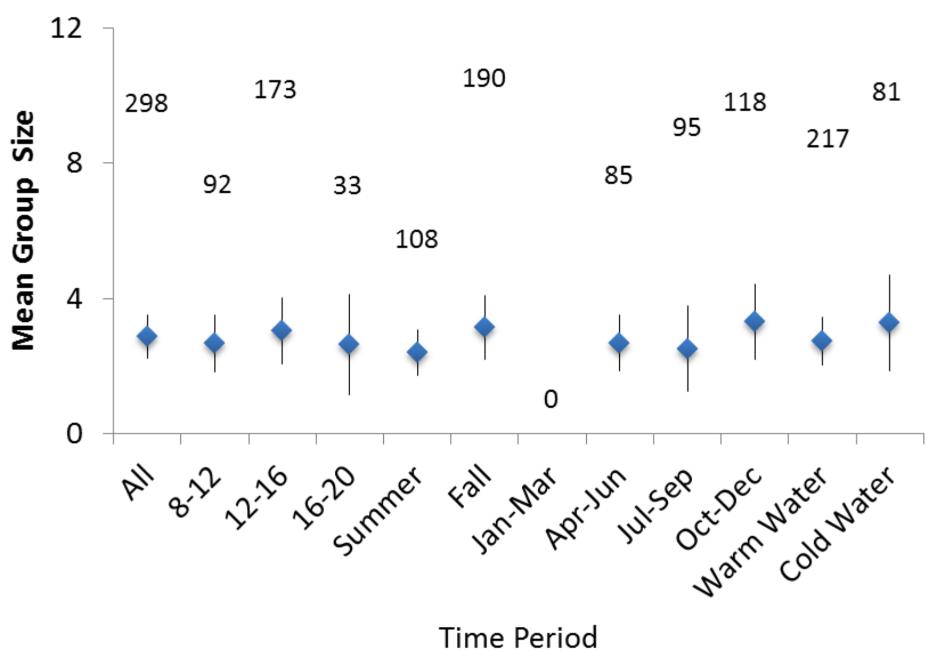

Figure 9. California Sea Lion Zalophus californianus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

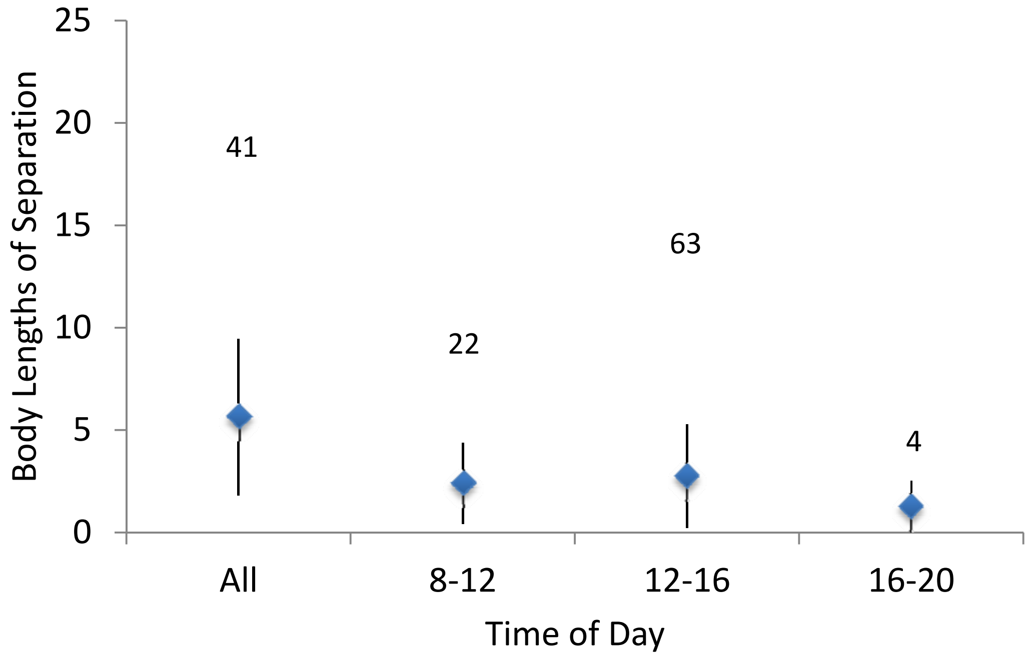

Figure 10. California Sea Lion Zalophus californianus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

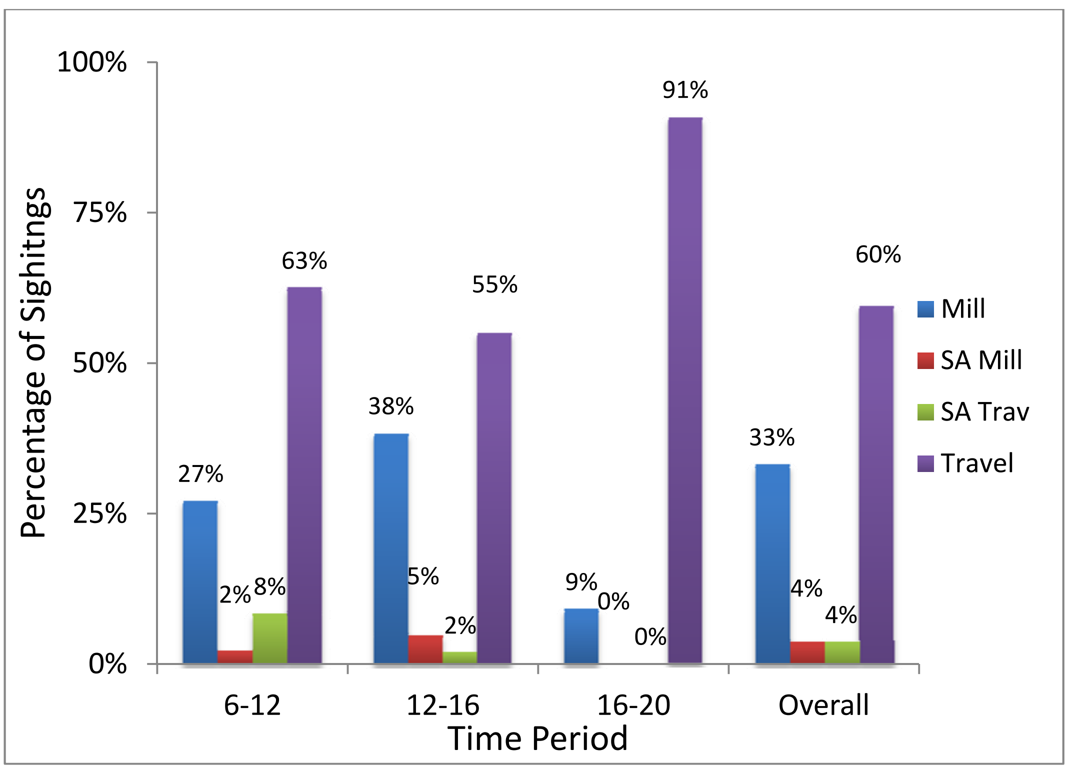

Figure 11. California Sea Lion Zalophus californianus initial behavior observed by time of day. Note: SA=surface active.

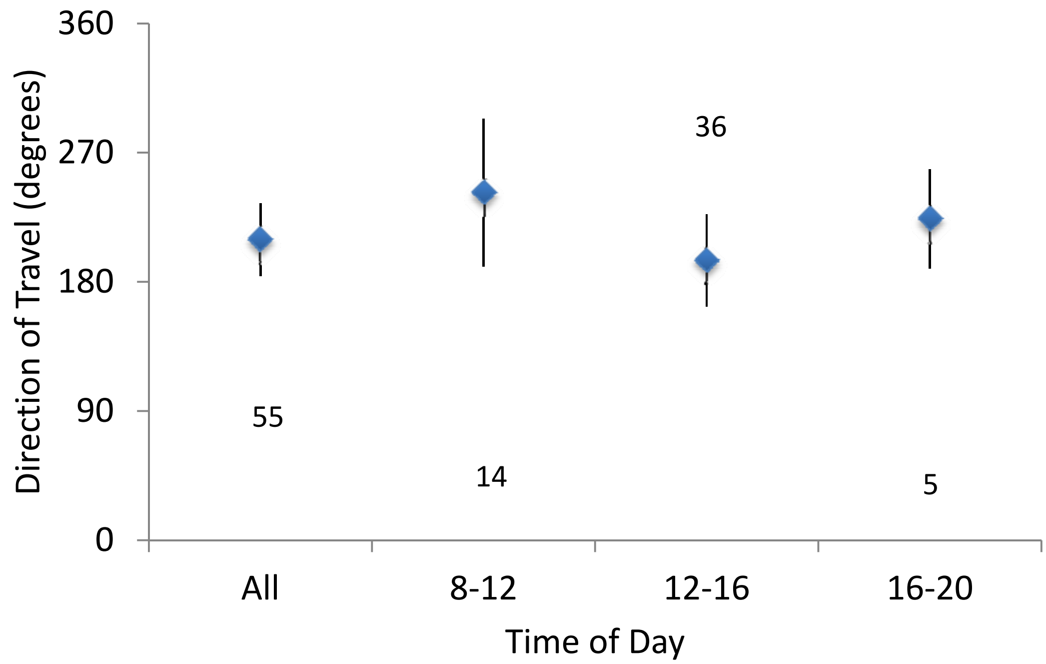

Figure 12. California Sea Lion Zalophus californianus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

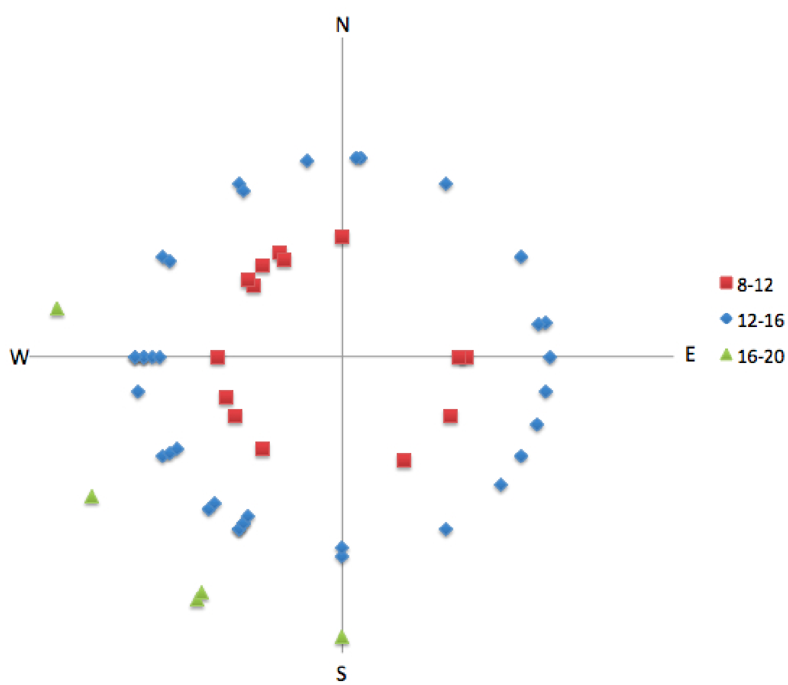

Figure 13. California Sea Lion Zalophus californianus mean group heading (degrees magnetic) by time of day.

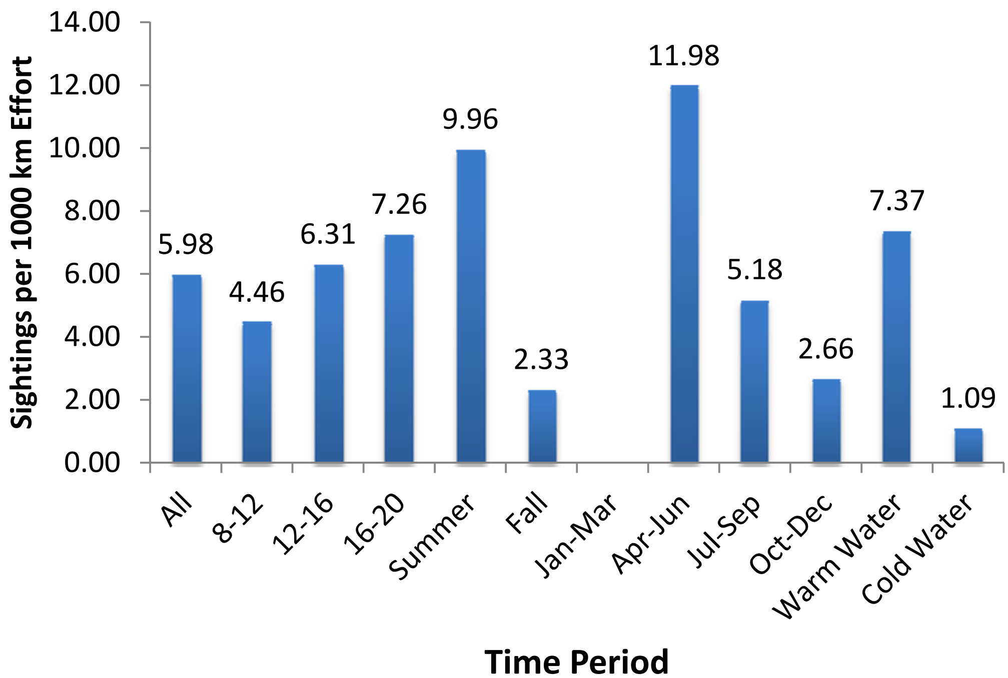

Figure 14. Risso's Dolphin Grampus griseus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

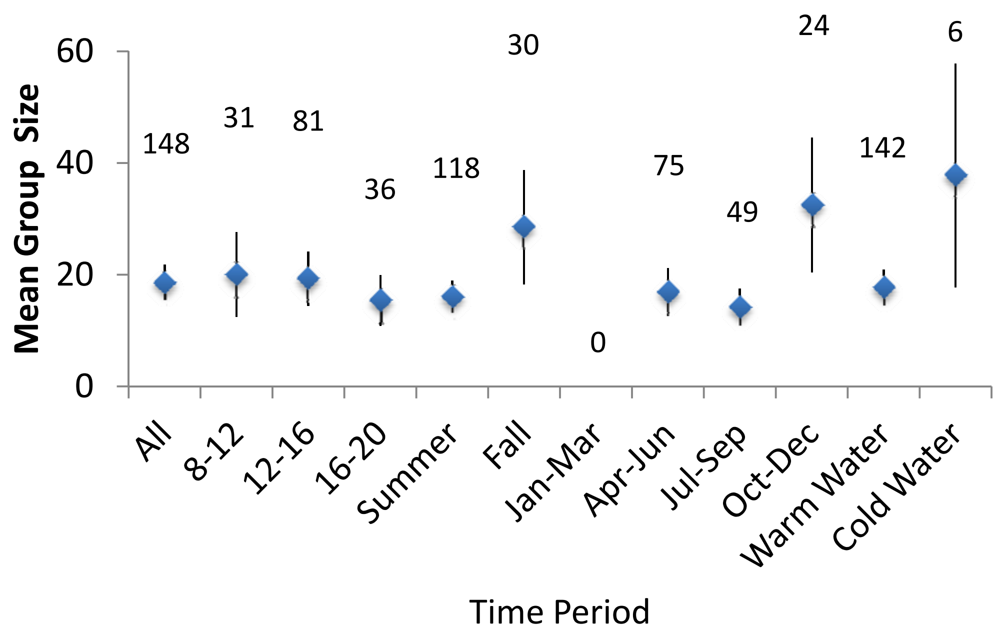

Figure 15. Risso's Dolphin Grampus griseus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

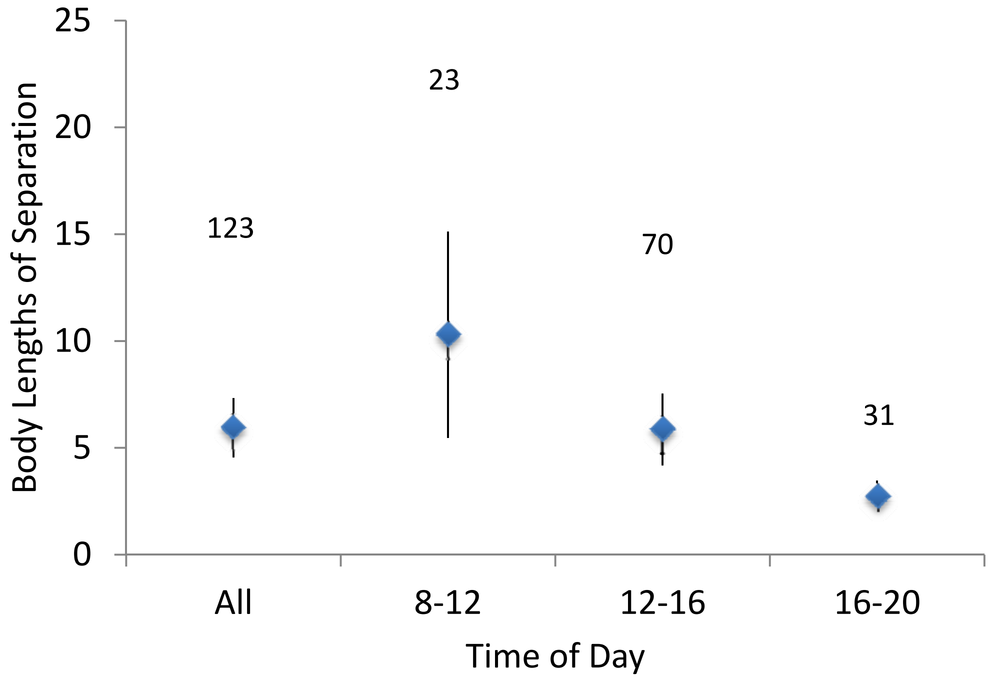

Figure 16. Risso's Dolphin Grampus griseus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

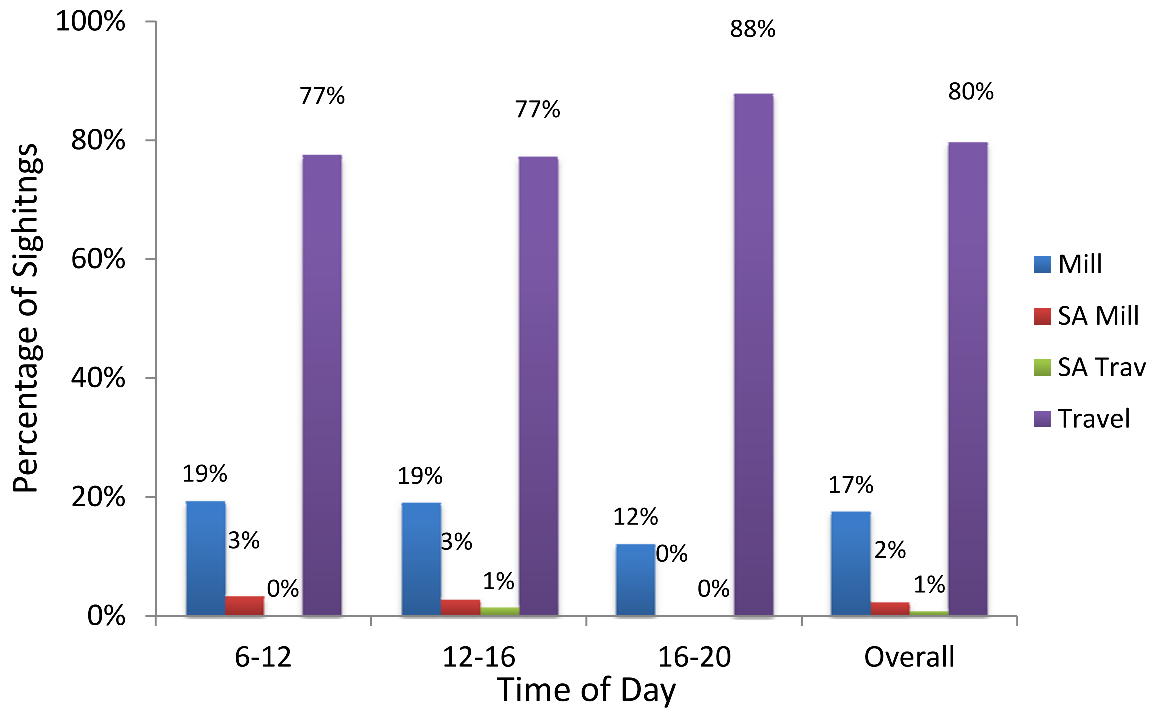

Figure 17. Risso's Dolphin Grampus griseus initial behavior observed by time of day. Note: SA=surface active.

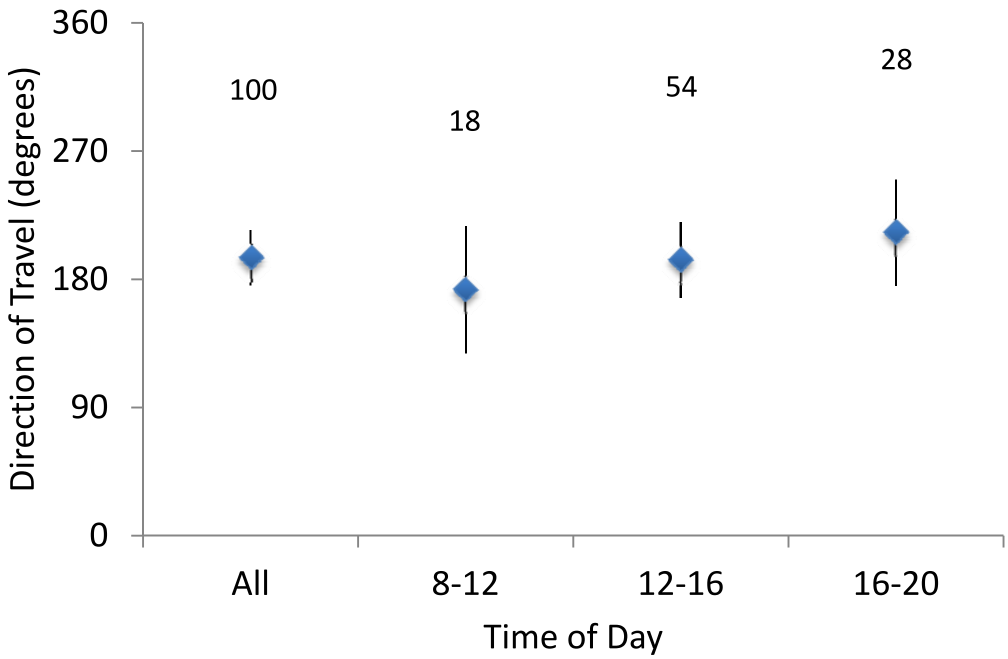

Figure 18. Risso's Dolphin Grampus griseus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

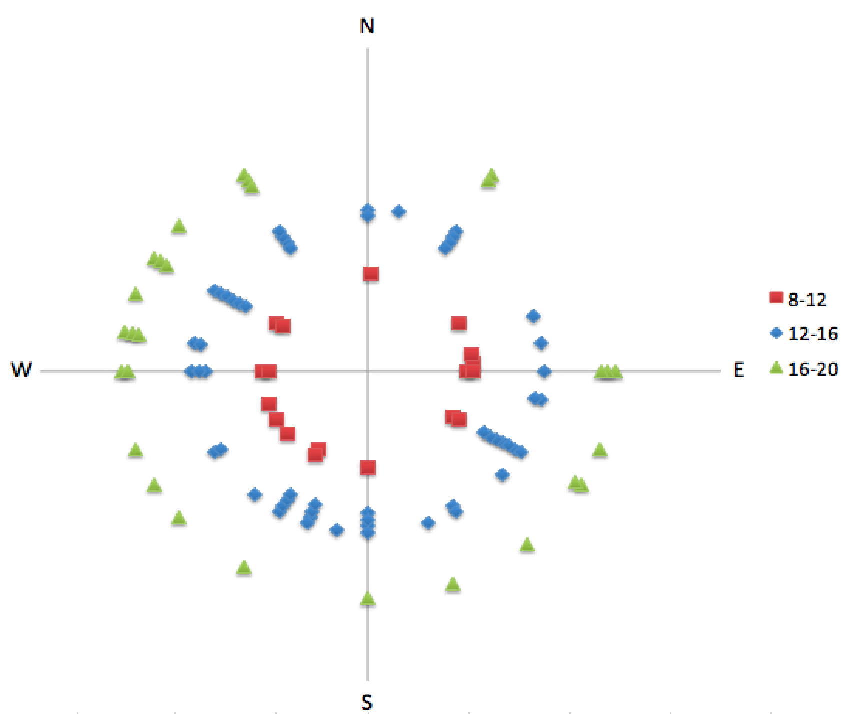

Figure 19. Risso's Dolphin Grampus griseus mean group heading (degrees magnetic) by time of day.

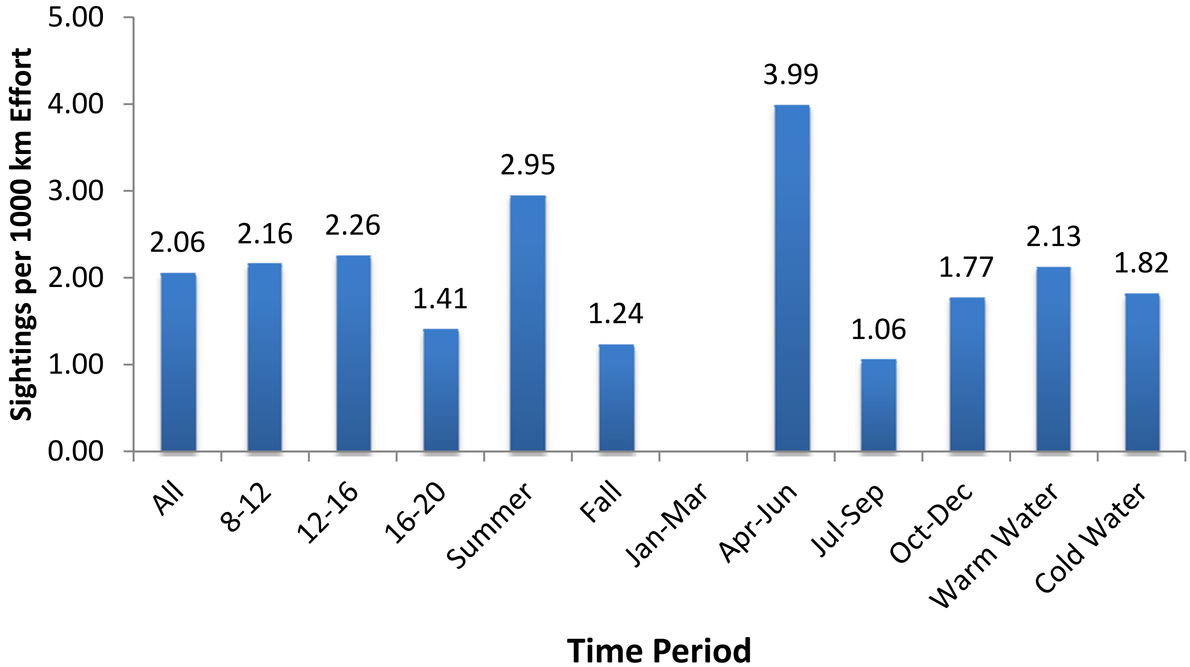

Figure 20. Fin Whale Balaenoptera physalus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

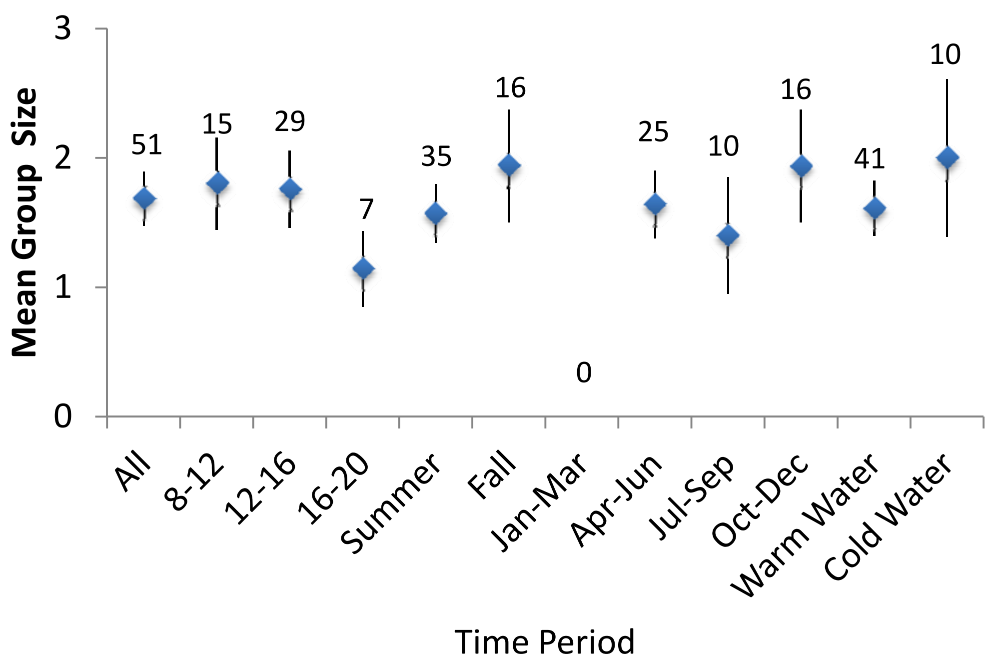

Figure 21. Fin Whale Balaenoptera physalus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

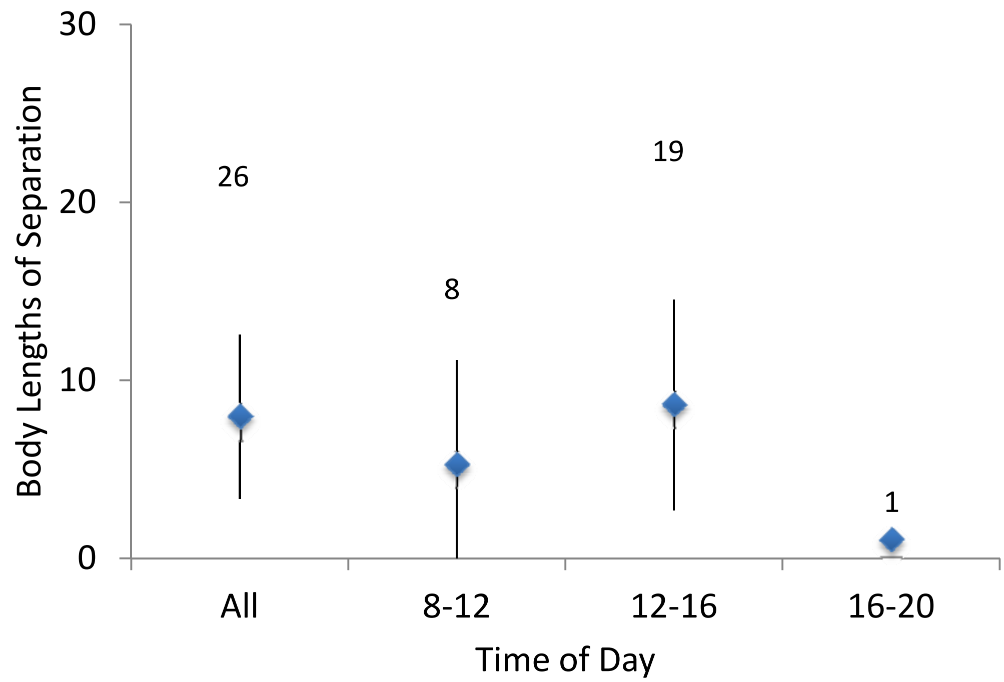

Figure 22. Fin Whale Balaenoptera physalus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

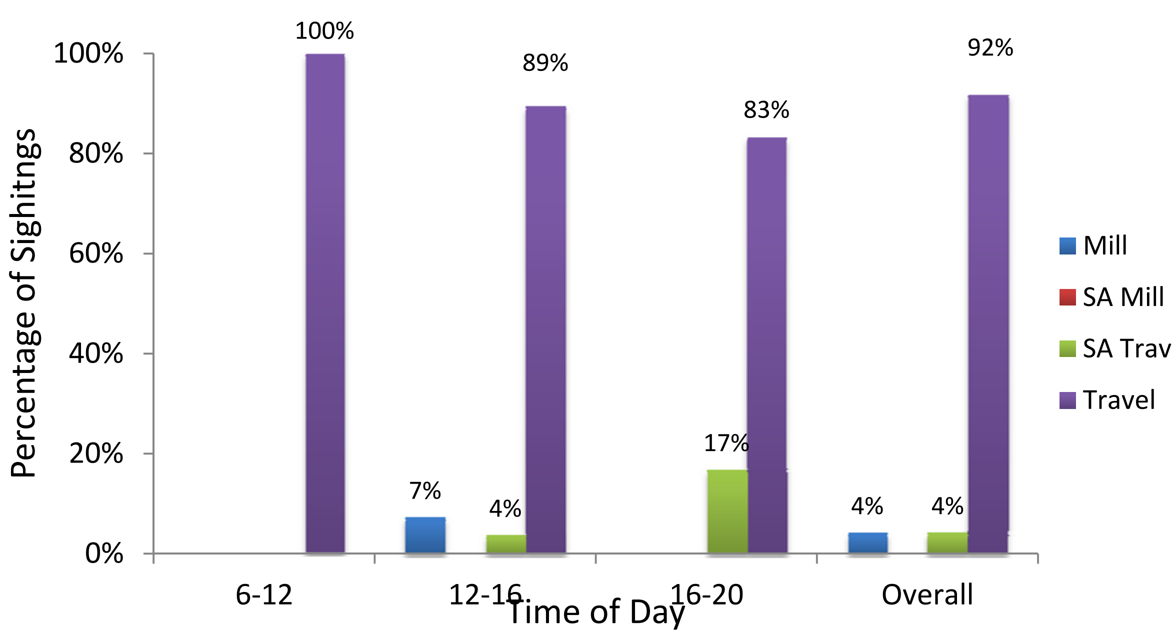

Figure 23. Fin Whale Balaenoptera physalus initial behavior observed by time of day. Note: SA=surface active.

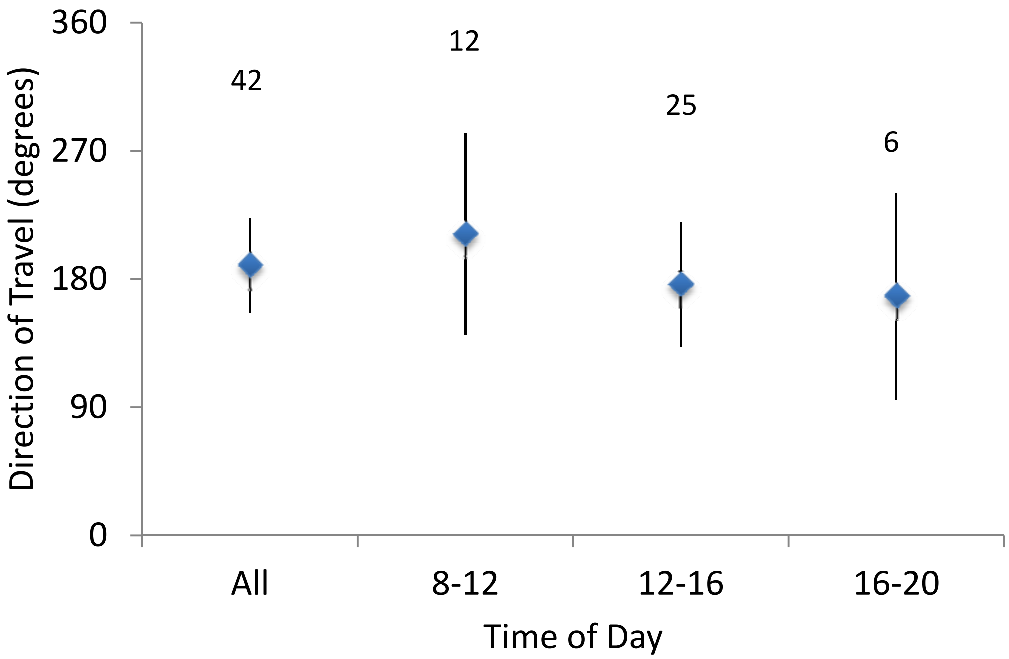

Figure 24. Fin Whale Balaenoptera physalus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

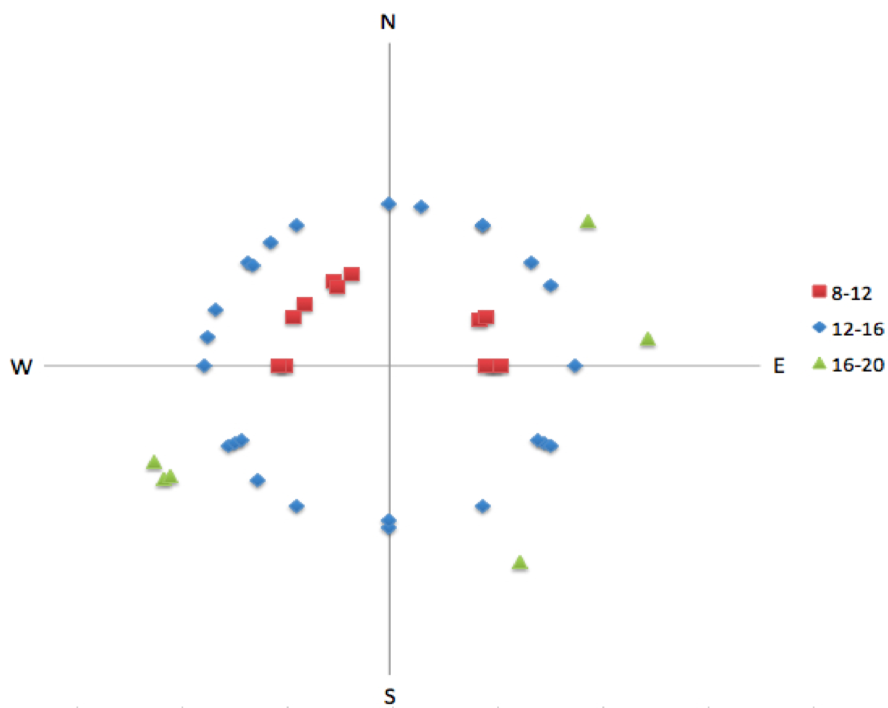

Figure 25. Fin Whale Balaenoptera physalus mean group heading (degrees magnetic) by time of day.

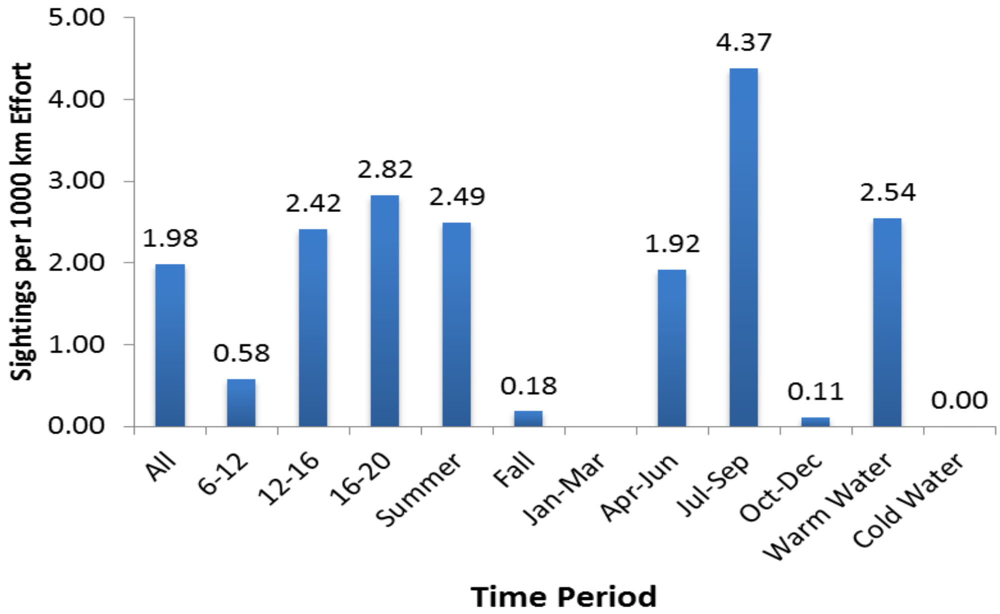

Figure 26. Blue Whale Balaeanoptera musculus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

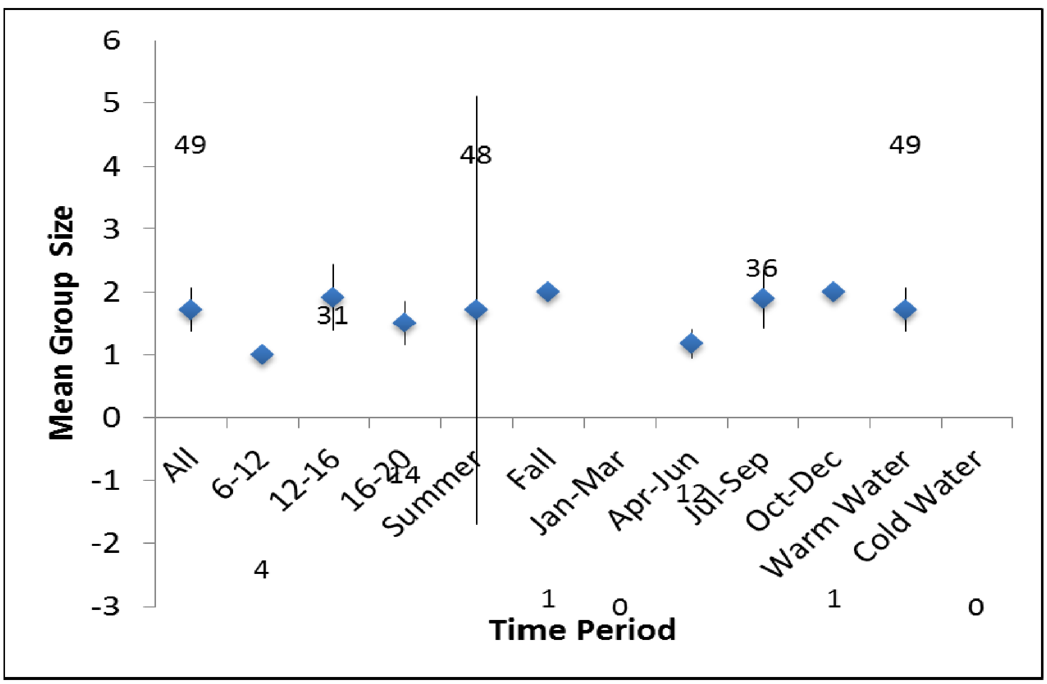

Figure 27. Blue Whale Baleanoptera musculus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

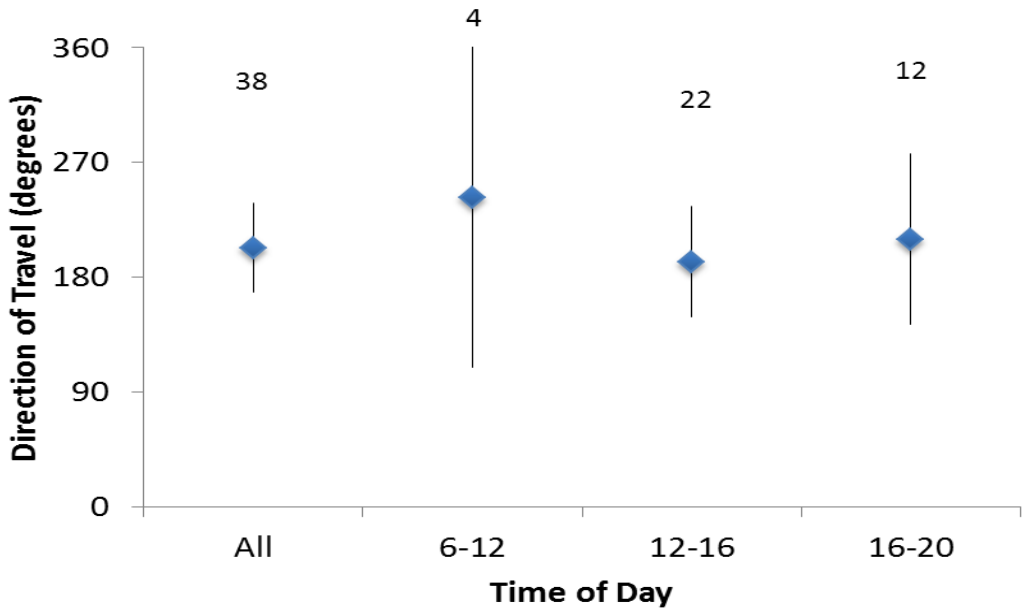

Figure 28. Blue Whale Baleanoptera musculus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

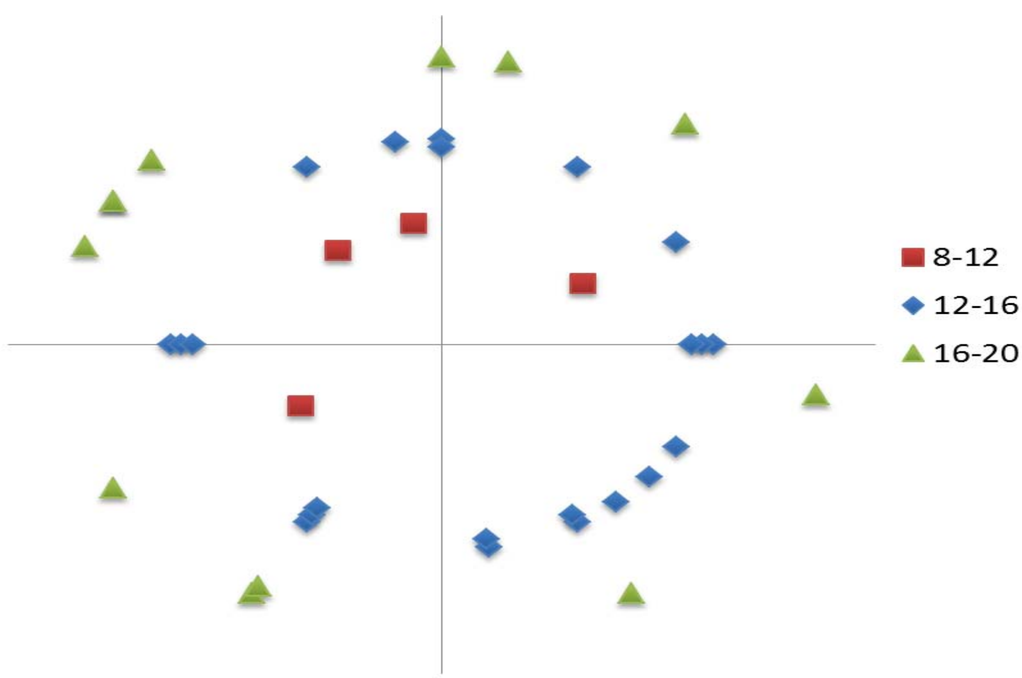

Figure 29. Blue Whale Baleanoptera musculus mean group heading (degrees magnetic) by time of day.

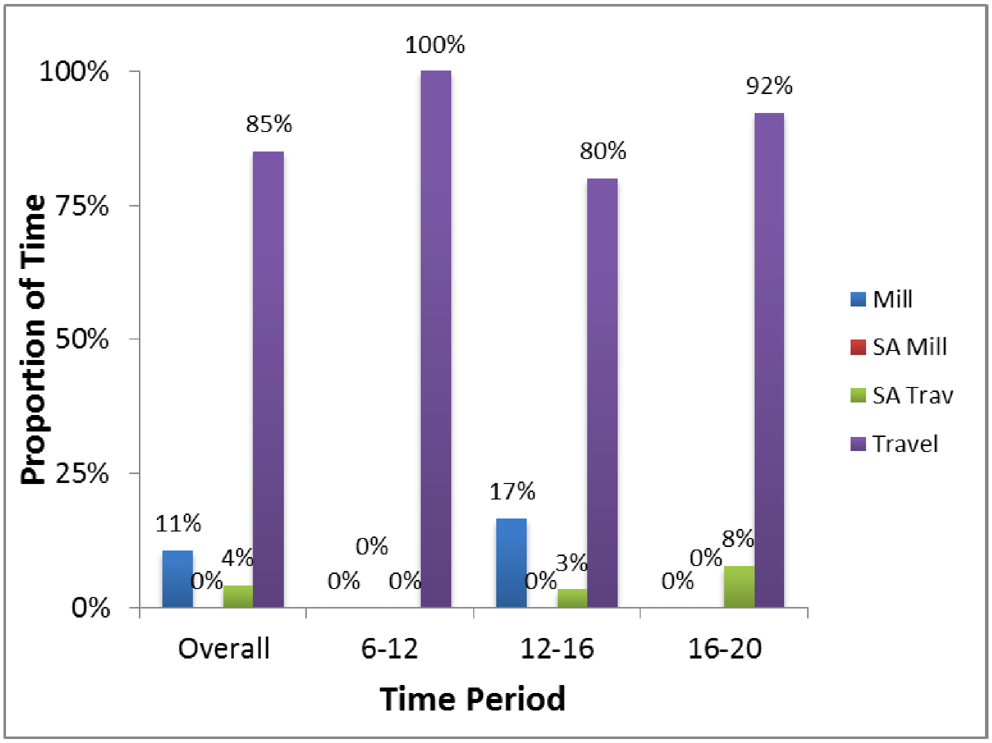

Figure 30. Blue Whale Baleanoptera musculus initial behavior observed by time of day. Note: SA=surface active.

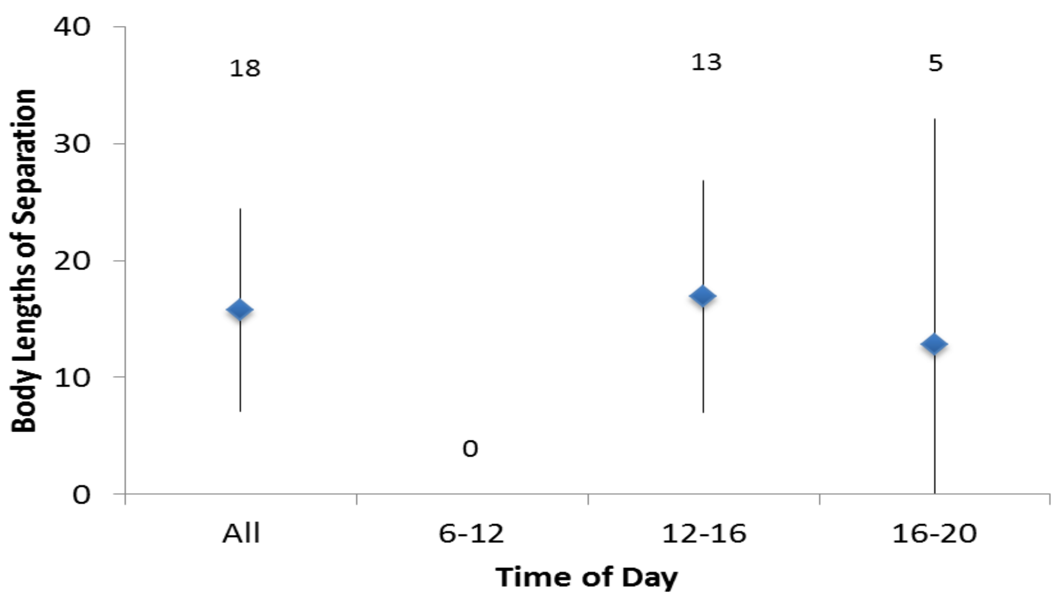

Figure 31. Blue Whale Baleanoptera musculus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

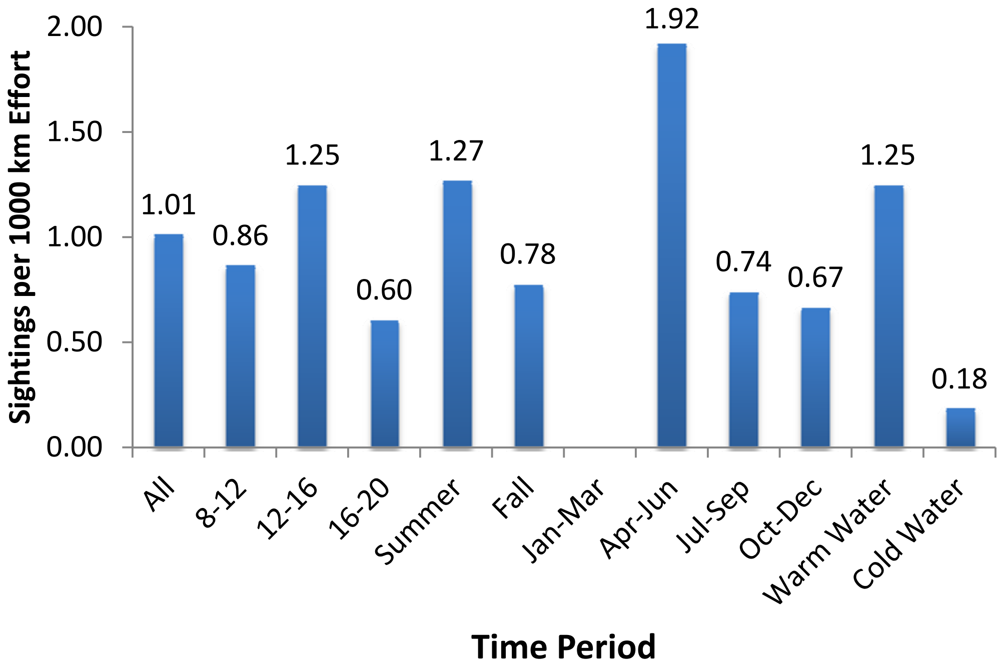

Figure 32. Bottlenose Dolphin Tursiops truncatus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

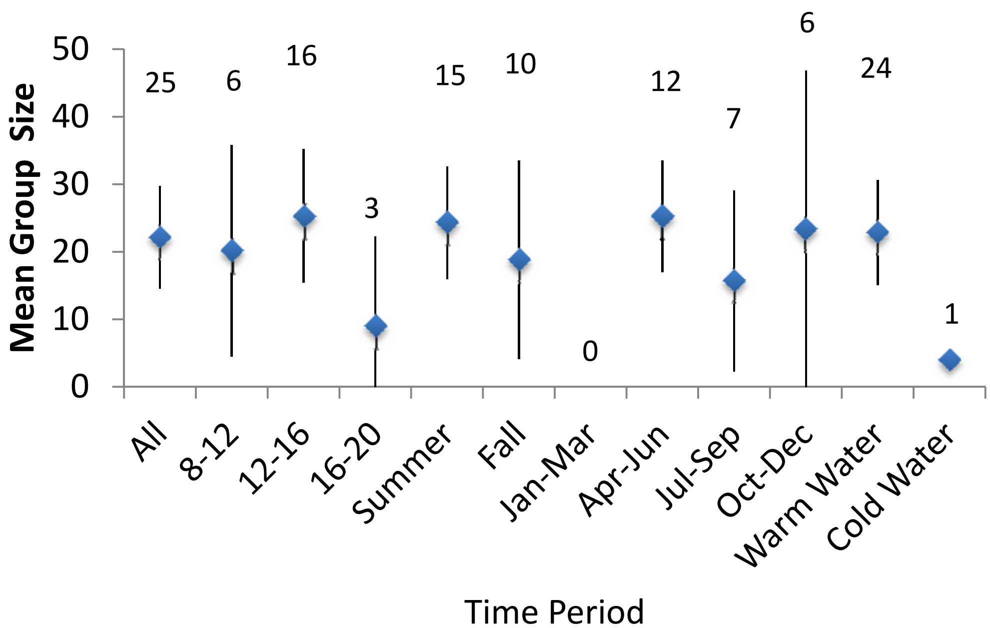

Figure 33. Bottlenose Dolphin Tursiops truncatus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

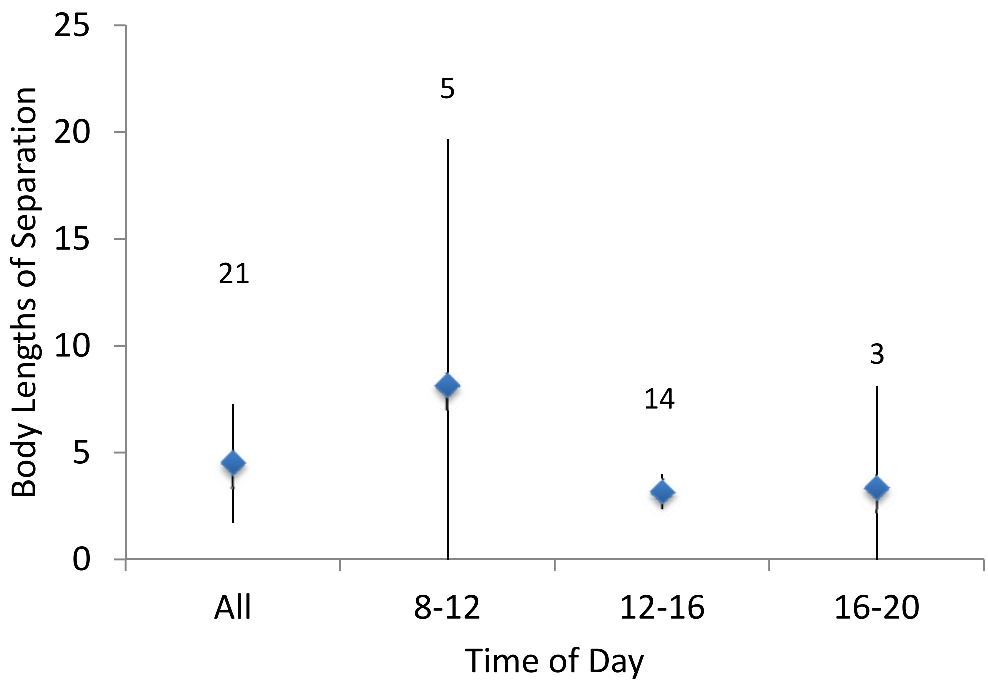

Figure 34. Bottlenose Dolphin Tursiops truncatus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

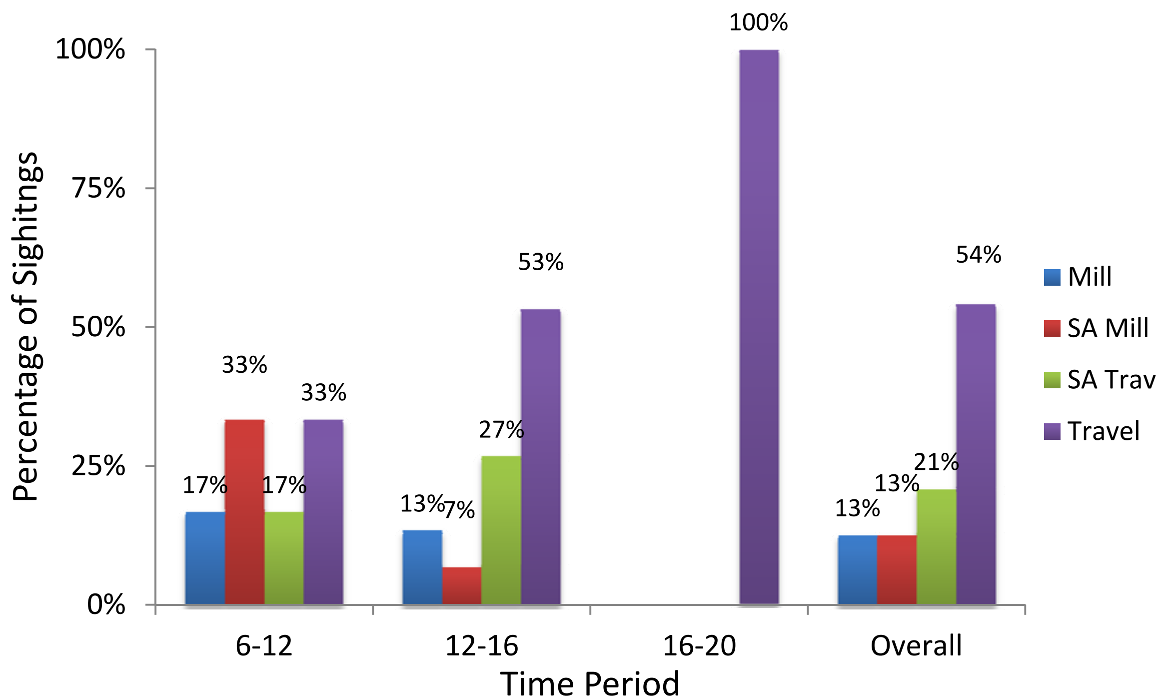

Figure 35. Bottlenose Dolphin Tursiops truncatus initial behavior observed by time of day. Note: SA=surface active.

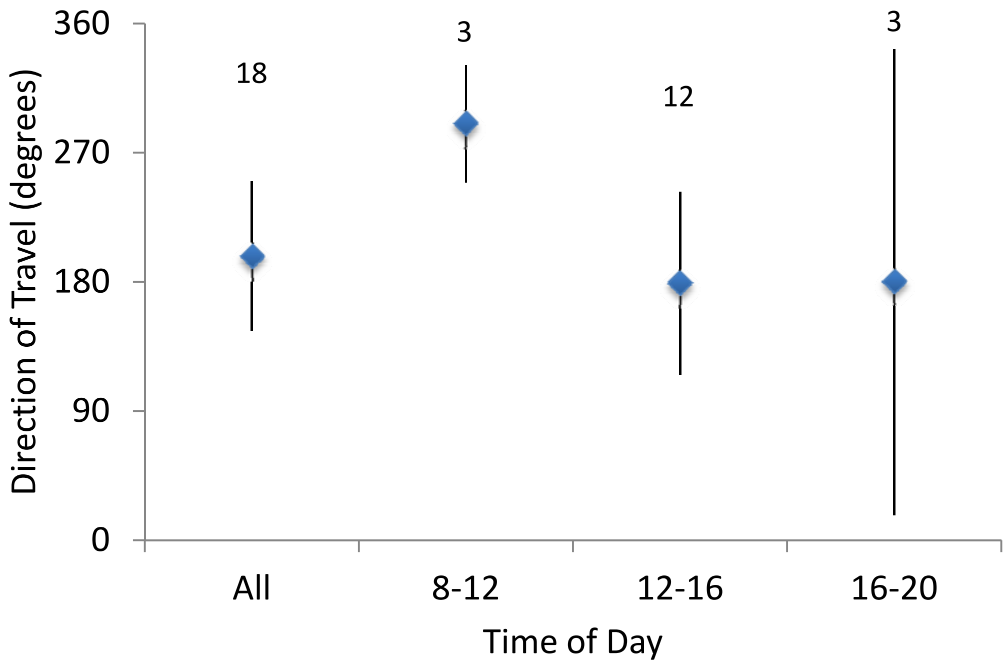

Figure 36. Bottlenose Dolphin Tursiops truncatus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

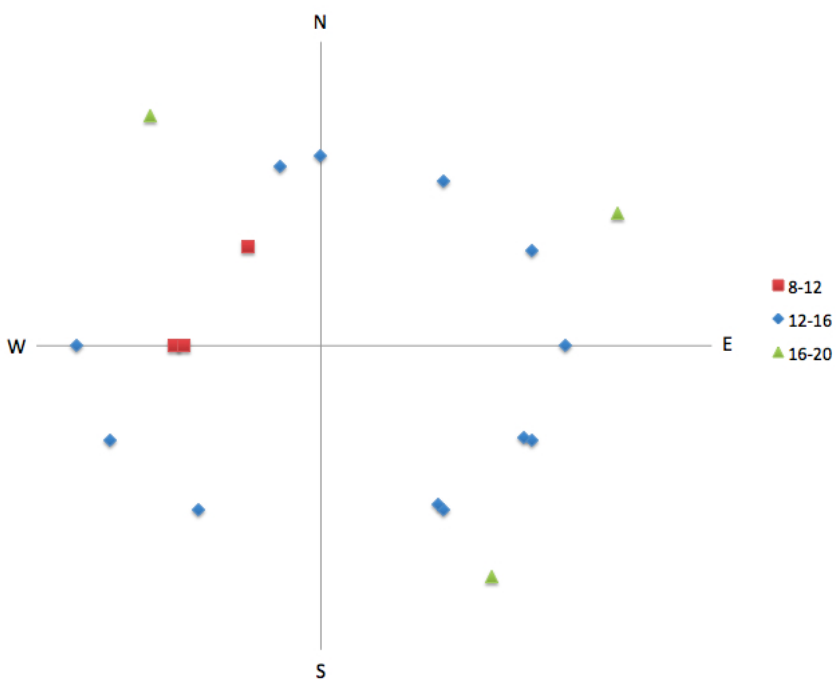

Figure 37. Bottlenose Dolphin Tursiops truncatus mean group heading (degrees magnetic) by time of day.

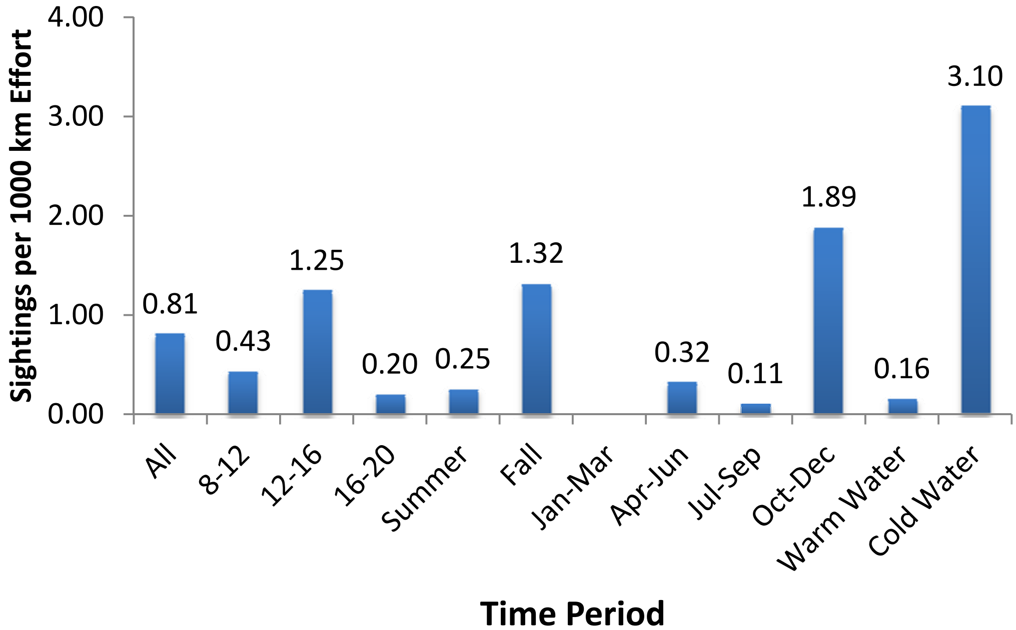

Figure 38. Pacific White Sided Dolphin Lagenorhynchus obliquidens sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

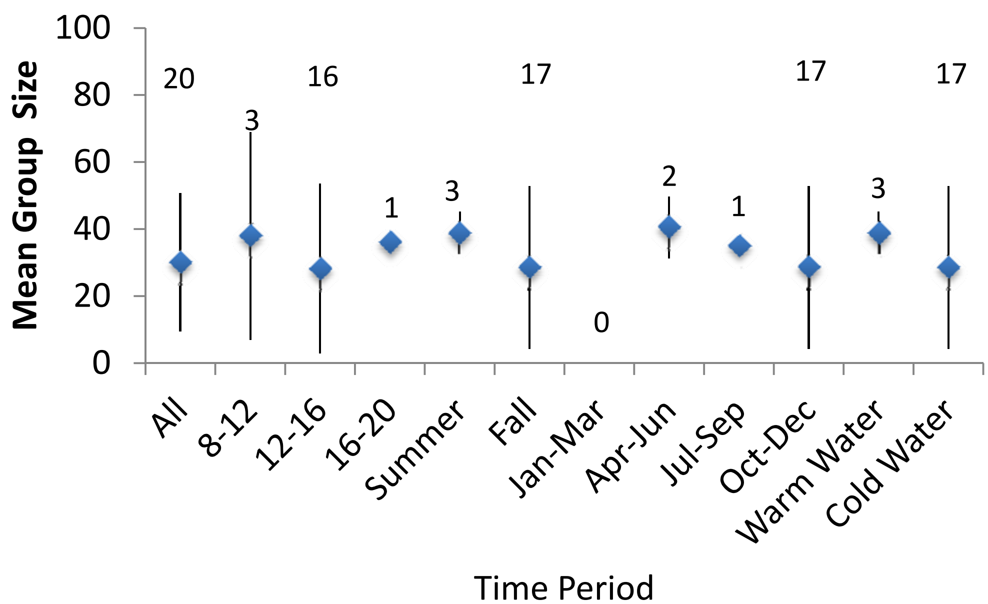

Figure 39. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

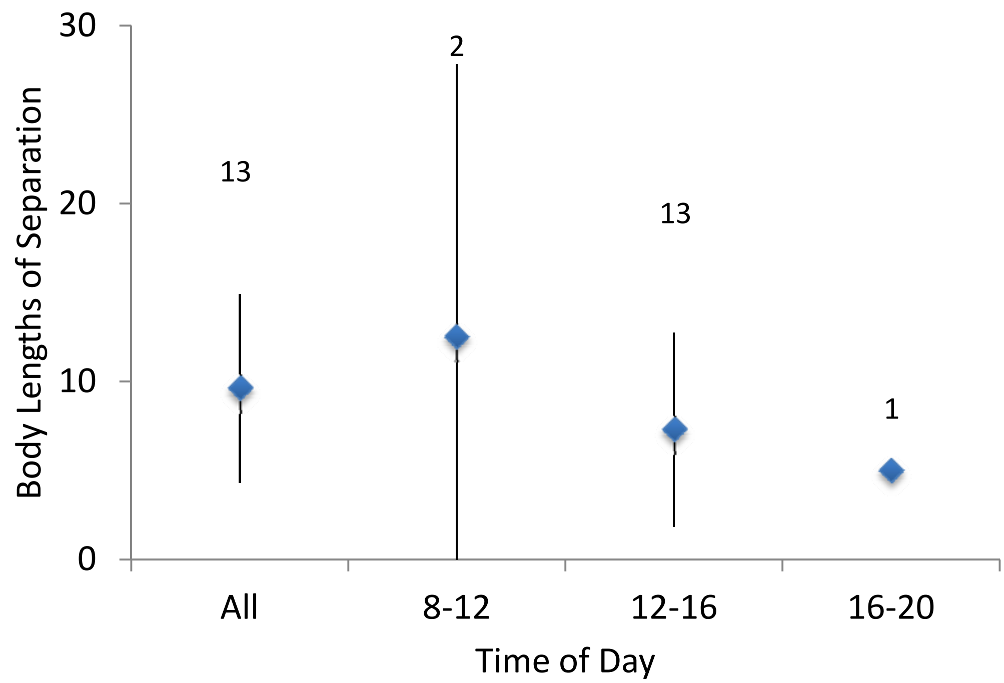

Figure 40. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

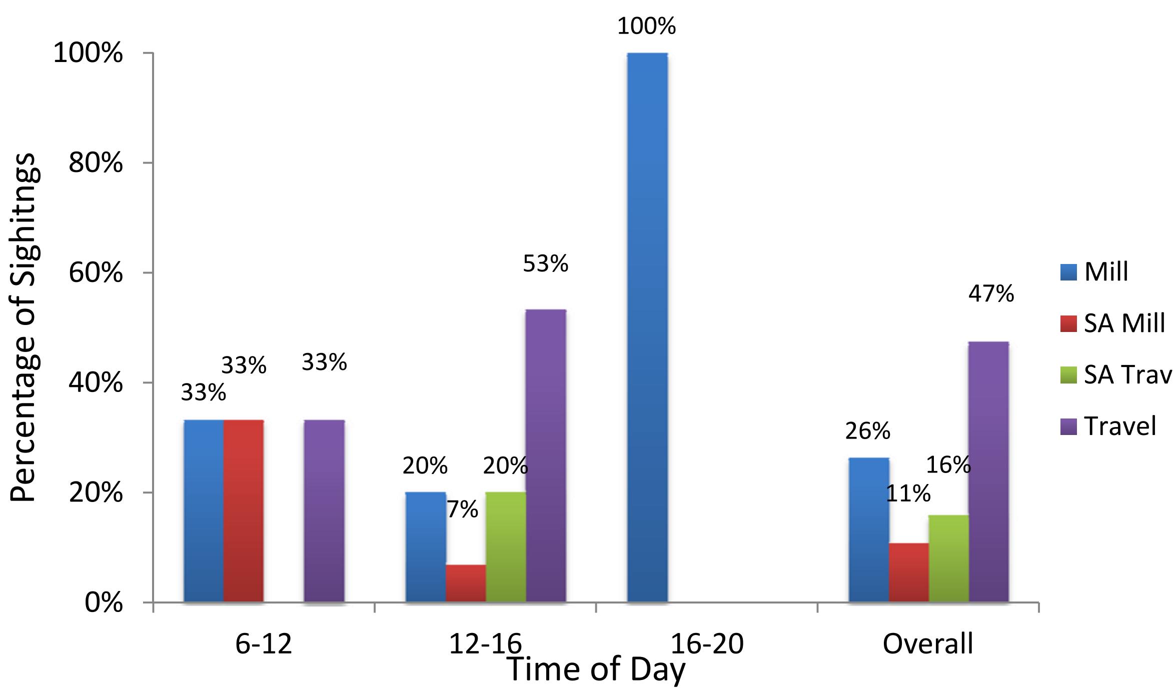

Figure 41. Pacific White Sided Dolphin Lagenorhynchus obliquidens initial behavior observed by time of day. Note: SA=surface active.

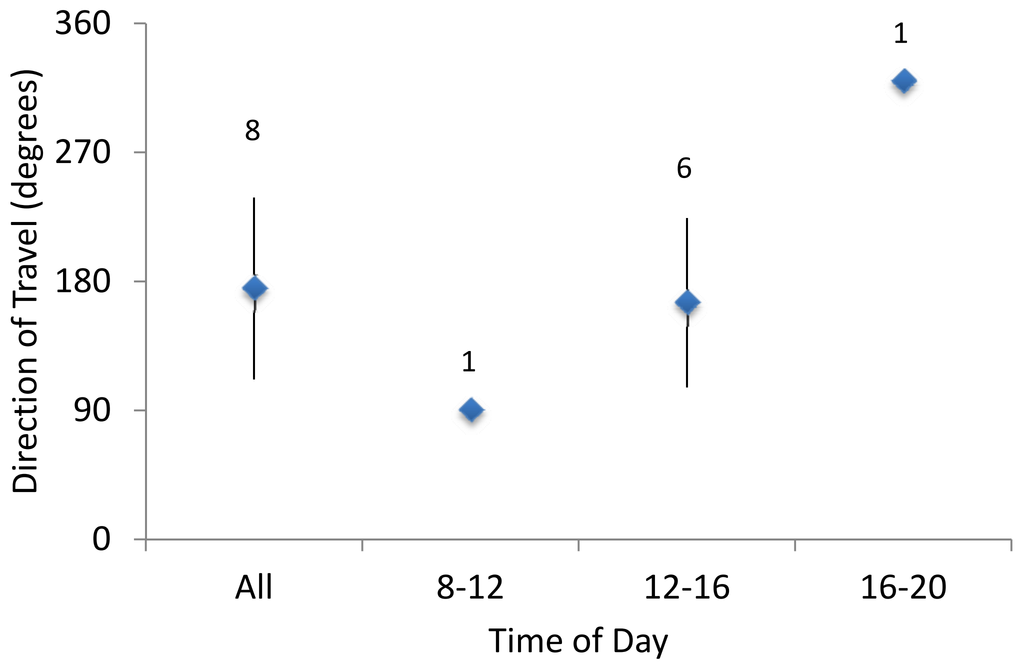

Figure 42. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

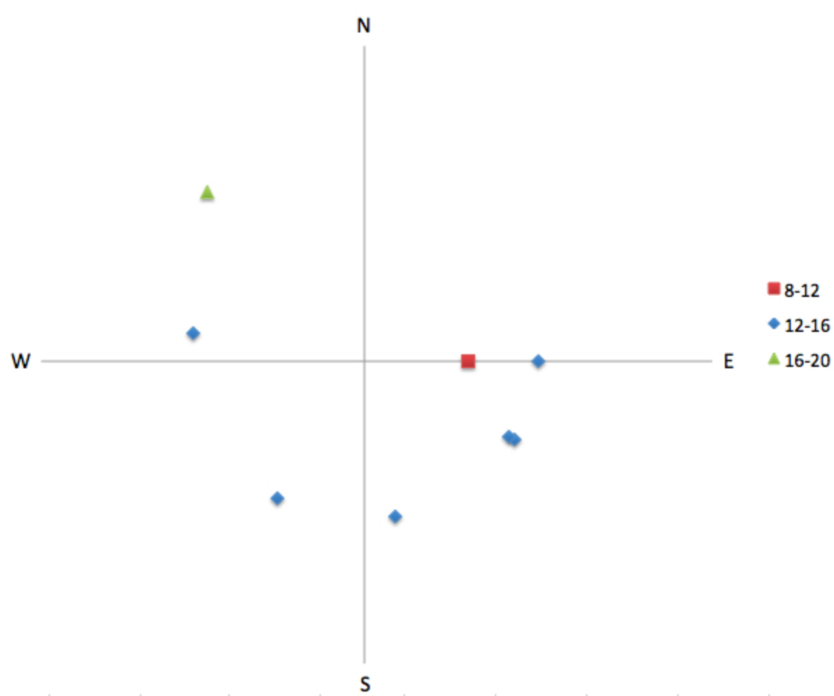

Figure 43. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean group heading (degrees magnetic) by time of day.

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MARINE MAMMAL AND SEA TURTLE MONITORING VIDEO DURING NAVY TRAINING EVENTS

Contract No. N62742-10-P-1818

Mari A. Smultea and Cathy Bacon
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29333 SE 64th St., Issaquah, WA 98027

Introduction

This report summarizes Contract N62742-10-P-1818 issued to Smultea Environmental Sciences (SES) in summer 2010 as described in the scope of work (SOW). The purpose of this contract was to review, catalog, inventory, transcribe and summarize HD video that had been collected during aircraft-based monitoring of marine mammals on behalf of the US Navy in the Southern California (SOCAL) Range Comlex and Hawaiin Range Complex (HRC) complexes during the period August 2008 through July 2009 by SES and Marine Mammal Reasearch Consultants (MMRC). As described elsewhere (e.g., Smultea et al. 2009, 2010), video data were collected to provide a detailed, reviewable media to document and describe the detailed behavior of cetaceans, focusing on priority species of marine mammals (e.g., federally listed species, Rissos's dolphins).

The primary goal of Navy funded behavioral monitoring of marine mammals is to provide a baseline to describe what constitutes typical behavior of marine mammals as observed at and just below the water surface (i.e., ~20-50 m below the surface). The latter data are to be used to assess potential effects of exposure to mid-frequency active sonar (MFAS). Past studies have shown that an aircraft circling cetaceans outside the received sound range of the aircraft (i.e., Snell's Cone) allows collection of undisturbed data that are not confounded (i.e., disturbed) by the platform of observation. In contrast, vessel surveys introduce noise into the water that has been shown to affect the behavior of some species and individual marine mammals (e.g., reviewed in Richardson et al. 1995; Southall et al. 2007; NRC 2003).

The occurrence, distribution, abundance, and vocalizations of marine mammals have been studied in the SOCAL and HRC complexes for several decades from aircraft, vessels, shore, and remote censusing techniques. Primary methods have included photo-identification, tagging, vessel and aerial-based line- transect surveys, passive acoustic monitoring and shore-based theodolite tracking (e.g., Tyack 1982; Baker and Herman 1984; Baker et al. 1985; Silber 1986; Mobley and Herman 1985; Frankel et al. 1995; Forney and Barlow 1998; Carretta et al. 2000). More recently, within the last decade, small-vessel-based satellite tagging and photo-identification efforts have revealed considerable information on dive, respiration, group characteristics, occurrence, distribution, range, and residency of many more obscure species in the HRC and SOCAL Range such as beaked whales and pelagic delphinids (e.g., Falcone et al. 2009; Schorr et al. 2010; Baird et al. 2011). However, very few social behavioral data have been collected, particularly in a systematic manner, with the exception of the humpback whale in the HRC. For example, much remains to be learned about basic behavioral budgets, level and rates of socializing/touching, short-term movements, inter-individual interactions, and group composition and size relative to vocalization patterns, among other variables. This information is critical to better understanding the context and factors influencing behavior, including vocal behavior. Furthermore, virtually nothing has been published on the social or basic behavior of some of even the most common species occurring there, especially in the SOCAL Range Complex, including blue and fin whales and Risso's dolphins.

Numerous studies have shown that some behavioral variables are affected by anthropogenic and other disturbance. Resulting responses have been successfully quantified and measured using behavioral parameters including dive and surface time, respiration rates, orientation/headings, and behavioral state among others (reviewed in Richardson et al. 1995). Using video to collect, analyze and interpret behavior has been shown to be an effective and useful tool to record and quantify these parameters for bowhead and humpback whales and bottlenose dolphins (e.g., Würsig et al. 1985, 1989; Richardson et al. 1985; Smultea and Würsig 1991). This approach has not been heretofore applied to other species until the recent aircraft-based behavioral monitoring in the SOCAL Range Complex and HRC. Video provides a media that can be reviewed repeatedly to obtain detailed, accurate behavioral data and identify behaviors missed in-situ during field work. Post-field comparisons of behavioral data collected in-situ with the same data collected, viewed and transcribed from video have shown that behaviors are missed in-situ or incorrectly identified but can be corrected during review of the video.

This report summarizes the methods used to collect, summarize, inventory, and transcribe video of seven species of marine mammals in the SOCAL Range Complex and HRC, as requested in the associated SOW. It also includes a discussion of the technical and other issues encountered during this process and how they have been addressed and/or improved upon. Given the relatively limited projects and species to which videography has been used to describe cetacean behavior, the technique is still relatively novel, it's utility of videography has not been fully explored beyond the extensive such studies done on bowhead whales relative to the seismic industry in the Beaufort Sea (e.g., Würsig et al. 1985; Richardson et al. 1985, 1995), bottlenose dolphins relative to an oil spill in the Gulf of Mexico (Smultea and Würsig 1991), and unpublished baseline data on humpback whales in Hawaii (e.g., Smultea et al. 1994).

Methods

Video was collected during four aerial surveys in SOCAL Range Complex and two aerial surveys in the HRC conducted from August 2008 through July 2009. Table 1 summarizes these videos including the dates they were taken and other associated information. Behavioral video collection protocol is described in Smultea et al. (2009, 2010, etc), as this report is more focused on how video was processed during the post-field period.

Video was collected using an HD Canon Vixia HF10 video camera with 12x optical zoom lens and a built-in optical internal stabilizer. This video camera was equipped with a flip-out LCD viewing screen as well as a short ocular viewing lens. Video were collected from altitudes of 366-457 m (1,200-1,500 ft) and a radial distance of ~1 km (0.5 nm) to the maximum extent practicable to remain well outside Snell's sound cone (Figure 1) below an aircraft. For example, at an altitude of 457 m (1,500 ft), Snell's sound cone radius is ~100 m during calm Beaufort sea state conditions over deep water (see Table 2 for the radial width of Snell's theoretical sound cone at various altitudes). When low ceilings precluded this, we flew at the highest altitude possible. Altitudes below 305 m (1,000 ft) were considered impractical for collecting data due to the difficulty in keeping the focal group in view as well as the risk of potential disturbance to them.

Videos were first reviewed in their entirety to identify and log periods when animals were in view, video general content, species, group size, and quality. Video quality was rated on a subjective scale to rate its utility with respect to the ability to identify and see individual behaviors, behavior states, etc. Factors that affected video quality included the occurrence of glare or the aircraft body periodically obscuring view of the animals (e.g., when the pilot turned sharply, the engine cowling or wing sometimes temporarily obstructed the view from the video camera); shaking of the video due to air turbulence or other factors; whether the animals were in view or focus, etc. Table 3 provides definitions of video quality that were applied.

Videos were reviewed a second time in their entirety to transcribe detailed behaviors. In this process, the video was paused, rewound, forwarded, and/or reviewed multiple times, as needed to identify and note pre-selected variables of interest based on visual and/or audio recorded data on the video. Data were entered into a customized Excel transcription spreadsheet. Prior to video transcription, an ethogram was developed to standardize transcription of behaviors. This ethogram was based on other studies and sources that had previously defined cetacean behaviors (e.g., Shane 1990; Baker and Herman 1984; Bauer 1986; Helweg 1989; Smultea 1991; Mann 1999, 2000; Perrin et al. 2009). Variables noted are provided in Tables 4 and 5. During transcription, unusual or previously undefined (in standard published ethograms) were identified and added to the original ethogram.

Scan sampling (Altmann 1974) was applied to systematically record the following variables at 30-sec intervals, as determined from viewing the video and/or hearing the video's audio: behavior state, heading (degrees magnetic), and minimum and maximum dispersal between nearest individuals within a subgroup (subgroup was defined as individuals behaving in a synchronized manner within 20 body lengths (BL) of one another). For whales, all-occurrence behavioral event sampling (Altmann 1974) was applied. Thus, all individual events/behaviors were recorded as possible/viewable/audible from audio, including respirations (blows), typical behaviors associated with dives and surfacing (e.g., first observed blow, no blow rise, peduncle arch, fluke up/down), conspicuous and previously defined (or sometimes novel) other behaviors (e.g., breach, tail slap, head rise, etc.), and any periods a behavior may have been missed. Individual respirations could not be reliably seen from most video for dolphins, especially larger group sizes of delphinids and their fluidity and the associated difficulty in keeping them all within view and/or altitude (457 m) relative to their body size. Thus, they were not recorded. However, such data could be discerned in a subset of these videos for a subset of individuals under ideal conditions (e.g., Beaufort sea state <3, calm air/no turbulence, no or minimum glare, etc.), especially for small groups of delphinids (e.g., <5-10 individuals) or individually discernible individuals within a group (e.g., a mother-calf pair).

Results

The video and metadata associated with this contract were provided to the NAVFAC Hawaii in May 2011 and included (1) two copies of all video, (2) an inventory list identifying all video taken, its contents, time, date, etc.; (3) an Excel spreadsheet for each cetacean sighting videotaped with transcription of behaviors based on video content and auditory video comment that included times and frequencies of individual behaviors, behavior states, headings, minimum and maximum nearest-neighbor dispersal distances between individuals, and general comments; and (4) the behavior ethogram.

Video was collected from a total of 30 focal groups of 7 species: 23 groups and 6 species in SOCAL Range Complex and 7 groups and 2 species in the HRC. Considerably more video was collected in the SOCAL Range Complex due to the higher density of animals and the overall much better Beaufort sea state conditions (e.g., mean Beaufort ~2-3 in SOCAL vs. Beaufort 4-5 in the HRC). A total of 181 min of video was collected in SOCAL vs. 52 min from the HRC. Video was of higher subjective quality in SOCAL vs. the HRC, generally due to the higher predominance of whitecaps in the HRC that often obscured detailed behavior of the focal group and the higher degree of turbulence associated with stronger wind speeds leading to shakier/less stable video.

Discussion

The first few aerial surveys were considered the feasibility phase of the aerial monitoring as described in the SOCAL Range Complex (DoN 2009) and HRC monitoring plans (DoN 2008). This phase was used to assess the utility of using video to collect behavioral data in the SOCAL and HRC complexes relative to the species and environmental conditions occurring there, as well as the aircraft platforms available within the limited budgets. It was found that more detailed behavior could be collected from certain species than others with video. For example, blue, fin, humpback, and minke whales could generally be reliably tracked for extended periods with the video. Risso's dolphins could also be reliably tracked in the SOCAL Range Complex given their whitish, light body color that could be tracked further below the water surface than darker species coupled with their tendencies to occur in relatively small group sizes (<20-25) and rest or travel slowly at or near the surface for extended periods (Risso's are considered a priority species in the Navy's SOCAL monitoring plan [DoN 2009]).

Equipment and methods used to collect video behavioral data were also modified during the feasibility phase of the aerial monitoring to improve the quality of the video. This included limiting video data collection to periods ideally with Beaufort sea states <4, from altitudes of 366-457 m (1,200-1,500 ft), and with minimal air turbulence. A chest monopod was also adopted after the first few surveys to increase the stabilization of the video camera and reduce the shaking of recoded video. Video could not be taken through the bubble windows due to distortion, and taking video through the flat Plexiglas windows decreased the clarity and resolution of the video; thus, video was collected through the one opening port in the plane's window from the front co-pilot seat.

There were a number of issues/problems encountered during post-processing of video. These issues along with how they were addressed are summarized in Table 6. The primary issues are briefly discussed below but described in detail in the table. The foremost issue was that the Canon video camera did not display real time after video had been recorded, i.e., when viewing it after it had been downloaded from the video camera. We contacted Canon but this feature was not available. The only measure of time on the downloaded video was a counter that counted video in seconds beginning with 0 whenever the video was started and restarted. This made transcription of video into real time a time-intensive process. However, in February 2011, specialized independent software was found on the internet in response to numerous complaints from video users that the video camera did not display time and date in other video viewing software. After purchase of this software, all video was then converted and displayed the real-time original time rather than the counter time. In addition, this display could be edited and the video could have titles inserted, etc. This made transcription of video much faster and less prone to potential error when converting counter time to real time. The video has an internal GPS and clock that automatically updates itself whenever it is turned on, so the time on the video matches the GPS time.

Another issue was that sometimes when video was copied, downloaded, or uploaded, resolution was lost or degraded in the process. This could be avoided by ensuring that the original resolution of the HD video was retained during the process. See Table 6 for additional issues and resolutions.

One ongoing issue is that it is very difficult to have no shaking on the video. The shaking was greatly reduced when we began using a monopod chest pod to help steady the video camera. However, in windy conditions resulting in air turbulence, shakiness persists due to the vibration of the aircraft itself. The shaking is annoying to transcribe, but these effects can be minimized by freezing video frames when viewing them to obtain the data of interest.

Conclusion

Video was successfully used to collect detailed behavioral data on species for which little or no socio-behavioral data have been collected. This method developed in the 1980s to document detailed behavioral variables of bowheads in a format that could be repeatedly reviewed was successfully applied to numerous novel species in the SOCAL monitoring. Techniques, approaches and methods were fine-tuned and modified over the course of the first six aerial surveys discussed herein. These modifications have improved the quality and utility of the video. However, further research into the feasibility of using more expensive and high-tech equipment to further minimize shaking of video is desirable (e.g., a gyroscope, etc.).

While video behavioral data were transcribed and inventoried for this project and contract, they remain to be quantitatively summarized with summary statistics. The latter is necessary to identify the variance around the mean of various variables of interest to determine what sample size would be required to enable recognition of a significant change from normal behavior, such as a potential response to exposure to mid-frequency active sonar.

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Table 1. Overall inventory library of marine mammal video taken during aerial monitoring conducted on behalf of the Navy in the HRC and SOCAL range complexes March 2008-July 2009.

Note: no video taken of sea turtles; sea turtles seen only in HRC

Survey Area	Survey Name	Survey Date	Video Taken	Species Videotaped	Total Video	SES Recommend Detailed Transcription?	Comments
HRC							
HRC	RIMPAC	24-30 March 2008	no	none	0	na	no video taken
HRC	RIMPAC	13-17 July 2008	no	none	0	na	no video taken
HRC	SCC OPS	18-21 August 2008	yes	spinner dolphins	0:07:15	yes	first time video taken from plane
HRC	SCC OPS	15-19 February 2009	yes	humpback whales	0:45:00	yes	see SCC OPS HI Feb 09 tab
HRC	SCC OPS	26-30 August 2009	no	none	0	na	no video of marine mammals, only a few sightings seen briefly
SOCAL							
SOCAL	JTFX	17-21 October 2008	yes	Risso's dolphin, common dolphin sp., fin whale, unidentified dolphin	0:35:22	yes	
SOCAL	Post-JTFX	15-18 Nov 2008	yes	humpback whale, blue whale, fin whale	0:58:57	yes	excellent video of whale behavior during low Beaufort above and below surface, possible courtship behavior, socializing

Survey Area	Survey Name	Survey Date	Video Taken	Species Videotaped	Total Video	SES Recommend Detailed Transcription?	Comments
SOCAL	JTFX	05-11 Jun 2009	yes	fin whale mother/calf with N. right whale dolphins, blue whale, humpback whale	1:27:21	yes	rare video of interspecific interactions between N right whale dolphins and mother/calf fin whale; very little known about social beh. of these species
SOCAL	Post-JTFX	20-28 July 2009	yes	Risso's dolphin, common dolphin sp., blue whale, unidentified whale	0	na	video backed up to 3 HDs but all 3 HDs malfunctioned/ failed; no video available; sent HD to data retrieval service: estimated $1200 to assess if data can be retrieved/not guaranteed

Table 2. Radial distance from aircraft of Snell's theoretical sound cone at various altitudes.

Aircraft Altitude (feet)	Clinometer Angle (degrees)	Radial distance (feet)	Radial distance (meters)
500	77	115	36
600	77	138	43
700	77	161	50
800	77	185	57
900	77	208	65
1000	77	231	72
1100	77	254	79
1200	77	277	86
1300	77	300	93
1400	77	323	100
1500	77	346	108
1600	77	369	115

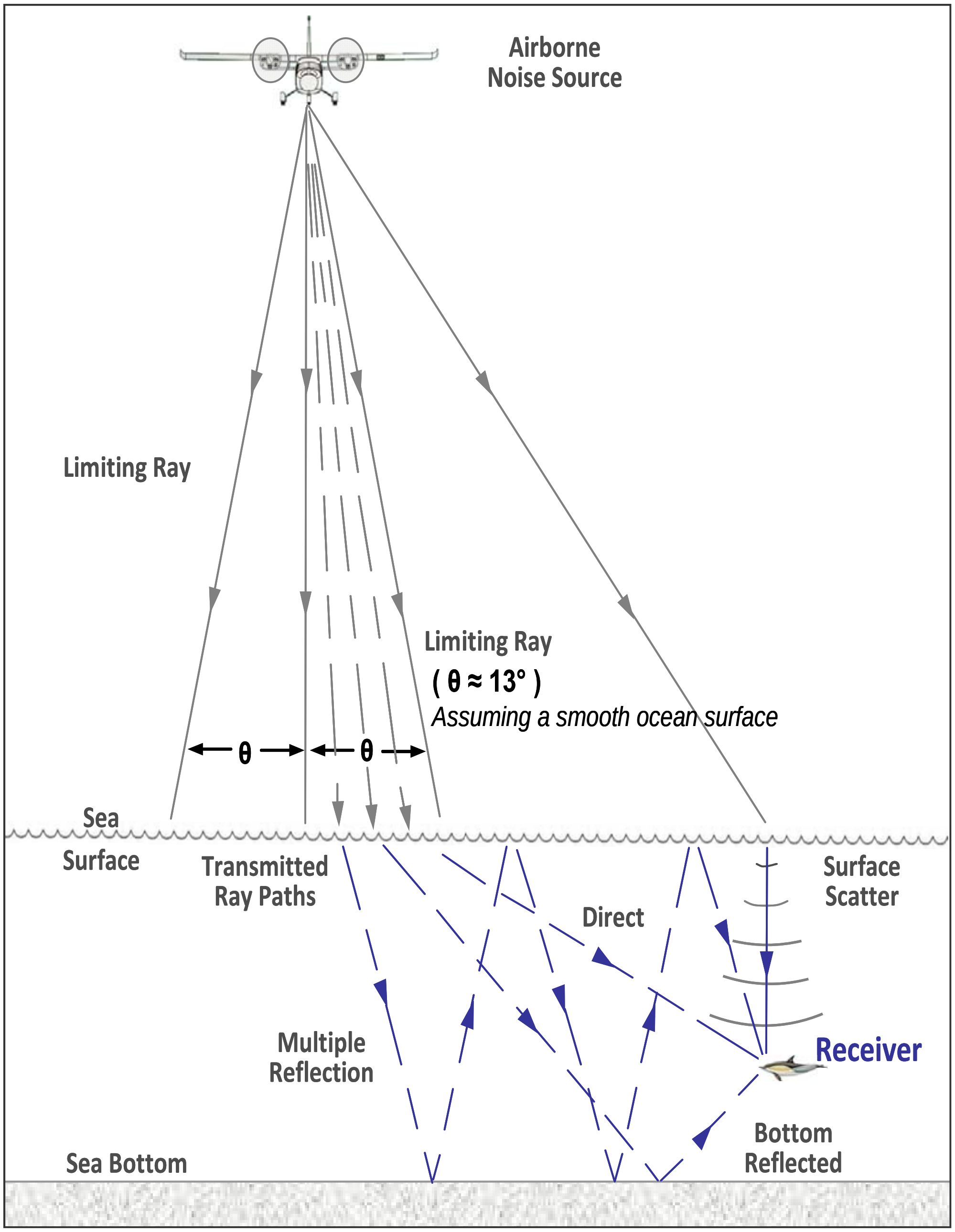

Figure 1. Diagram illustrating the theoretical 36-degree inverted sound cone (radius 13 degrees) within which the noise ray of an overflying aircraft is limited at the sea surface under calm, flat sea conditions. Also illustrated are ways in which the transmission of sound rays though the water surface can be influenced by water-depth reflection. Increasing disturbance of surface waters (i.e., increasing Beaufort sea state) can increase the size of the radius beyond the theoretical 26-degree sound cone. (Diagram from Richardson et al. 1995).

Table 3. Definitions used in assessing the utility and quality of video taken during marine mammal monitoring conducted on behalf of the Navy in the SOCAL and HRC range complexes October 2008-July 2009.

Video Quality	Definition
Poor	Behavior and audio indiscernible. E.g., animal never seen in video or behavior cannot be determined because animal too far away, video shaky/out of focus/moving too much, Beaufort sea state too rough (i.e., can't determine dispersal distance between individuals, blows and (for whales), individual surface-active behaviors, and/or orientation of animal), and/or audio cannot be understood due to interference/static noise or was not recorded.
Fair	Some behavior and most audio discernible. E.g., animal seen in video and behavior, orientation, and dispersal can be determined but in view on video for only a short period of time (<30 sec per video clip). Most audio can be understood.
Good	Most behavior and audio discernible. Most periods animal at or near surface are captured on video and most audio is understandable. Animal seen in video for a longer length of time (e.g., >30 sec per video clip) and can determine behavior. Nearly all individual behavioral events, blows (for whales), behavior state, orientation, and dispersal distances can be determined via combined video and/or audio.
Excellent	Behavior easily discernible all times animal in view below/above surface and audio discernible. E.g., animal(s) seen throughout entire video when visible at or below the water surface and all audio can be understood. All behavioral events and blows (for whales), behavior state, heading, and dispersal distance can be determined. Video footage is relatively steady and focused. Usually occurs when Beaufort sea state is less than 3.

Table 4. Behavior state and individual behavioral event definitions.

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	CODE	DEFINITION (e.g. Perrin et al. 2009, Shane 1990, etc.)
REST/SLOW TRAVEL	RE	>50% of group exhibiting little or no forward movement (<1 km/hr) remaining at the surface in the same location or drifting/traveling slowly with no wake
TRAVEL	TR	Slow travel = travels w/ no wake or white water. Medium travel = travel with wake but no white water. Fast travel = travel with wake and white water
MILL	MI	>50% of group swimming with no obvious consistent orientation (non-directional) characterized by asynchronous headings, circling, changes in speed, and no surface activity. Includes feeding.
SURFACE-ACTIVE MILL	SM	While milling, occurrence of aerial behavior that creates a conspicuous splash (includes all head, tail, pectoral fin, and leaping behavior events—see below) Includes feeding.

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	CODE	DEFINITION (e.g. Perrin et al. 2009, Shane 1990, etc.)
SURFACE ACTIVE TRAVEL	ST	While traveling, occurrence of aerial behavior that creates a conspicuous splash (include all head, tail, pectoral fin, and leaping behavior events—see below)
PROBABLE FORAGING	PF	Apparent searching for prey; the process of finding, catching, and eating food (Perrin et al. 2009)
UNKNOWN	UN	Not able to determine behavior state. (e.g., animals out of sight, too far to determine, on a dive, etc.)
OTHER	OT	Describe in notes
Individual Behavior Event		
Logging	LG	Lying at the surface with body exposed with no directed forward movement
Breach	BR	A behavior in which a marine mammal leaps out of the water (Perrin et al. 2009)
Porpoise	PO	The behavior of marine mammals leaping at least partially clear of the water surface during rapid swimming (Perrin et al. 2009)
Stern-ride	SR	The action or behavior pattern of riding on the pressure wave at the stern or abreast of a ship
Spin	SP	Leap clear of water and spin (dolphins only)
Bow ride	BO	The action or behavior pattern of riding on the pressure wave in front of the bow of a ship (Perrin et al. 2009) or the stern or abreast of a ship
Head Slap/Lunge	HS	Leap out of water w/ forward thrust or side at >40º and slap ventral surface on water creating large splash
Foraging	FO	Seen chasing fish or prey and/or zigzag pursuit swimming
Sprint	ST	Brief increase in speed often associated with foraging /feeding
Social	SO	Two or more animals in physical contact
Roll over	RO	Animal completely rolling over
Zigzag	ZZ	Swimming in a zigzag pattern
Tail Slap	TS	A behavior in which a marine mammal slams its flukes down on the water, usually repeatedly (Perrin 2009)
Pectoral Fin Slap	PS	Slap water surface with pectoral fin - ventral or dorsal up
Inverted Swim	IS	Animal swimming with ventral side up, dorsal side down - inverted
Unknown	UN	
Other Behavior	OB	Behavior not listed above: describe in notes

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	CODE	DEFINITION (e.g. Perrin et al. 2009, Shane 1990, etc.)
Missed Behavior	OMB	Did not see/missed a behavior
Whales Only		
Blow	BL	Visible respiration-cloud of vapor and sea water mixed with air that is exhaled by cetaceans (Perrin et al. 2009)
No Blow Rise	NB	Surface with no visible blow/respiration
Missed Blow	MB	A blow/surfacing is suspected to have been missed/not seen
First Blow	FB	First blow of surface sequence (where surface sequence consists of closely spaced blows usually followed by a dive)
Peduncle Arch	PA	Arching of peduncle (posterior portion of the body bearing the tail or flukes) without lifting tail/flukes
Fluke up	FU	Arching of back followed by lifting tail flukes into air (fluke facing up) usually before an extended dive
Fluke down	FD	Arching of back followed by lifting tail flukes into air (fluke facing down) usually before an extended dive
Un ID Large Splash	US	Large splash associated with an unidentified/unseen behavior
Vertical	VU	Vertical in water with head up
Vertical down	VD	Vertical in water with head down

Table 5. Codes and definitions developed and used during transcriptions of marine mammal behavior from video.

Behavior State Code	Definition
Codes When Behavior State Not Visible	
NVSS	Not visible due to animals being sub-surface
VSSNB	Visible sub-surface but no behavior discernable
NVGL	Not visible due to animals in glare
NVPL	Not visible due to animals under plane e.g. out of view under belly of plane or under wing
NVOF	Not visible due to camera out of focus or camera not centered on group
Group Shape	
C	Circular
L	Longer than wider oval
W	Wider than longer oval
T	Triangle
IT	Inverted triangle
LA	Line abreast (single file line horizontally)
LAL	Line abreast (single file line vertically)
V	V-shaped
IV	Inverted V-shape
U	U-shaped
IU	Inverted U-shape
IR	Irregular Shape
O	Other

Table 6. Issues and problems encountered and how they were addressed during development and application of using video to collect marine mammal behavioral data in the Navy's HRC and SOCAL range complexes 2008-2010.

Video Issue	Description of Problem	Resolution	Recommendations	Comments
Format	The video is in the format of the video camera (ex. Canon video recorders produce in a unique proprietary format). Format is incompatible with video playback software except the software that comes with the video camera.	A software program was purchased to change file format. Although the video can be viewed by many programs after conversion, the result is a significant investment of additional resources. Conversion is slow and utilizes enough RAM to make the system(s) used for the conversion inoperable until the task is completed.	Recorders have unique formats in order to compress files while recording. Each recorder has the software distributed with the hardware. All video should be recorded using one format (brand and model of recorder) and software should be distributed to all staff needing access to viewing videos.	There may be a requirement to purchase additional licenses for users. It will be important to note that if file conversion is continued, WAV is the preferred format. Other formats may compromise audio.
Access to files	File sizes are large. Uploading to FTP is time-consuming as is subsequent downloading.	Task was divided among users. Some files were distributed on portable, external hard drives mailed to staff. Egnyte (storage space on a server) was purchased to make access to files possible from any geographical location with internet access. This is a time-consuming process (see comments)	Files can be uploaded overnight on several machines. Task should be divided for efficiency. Bandwidth is the limiting factor for transferring files to shared data bases (for users over distance). Speeding up this process is costly. Important to upload and download in the same high-resolution as original video or resolution can be lost in the uploading, downloading, and copying process	It is not likely that purchasing more bandwidth to upload files will make good fiscal sense as long as analyzing data is not a 24-our operation. It may make sense to acquire an intern needing experience to perform data transfer, if a dedicated computer is available. Otherwise, a dedicated computer is needed and needs to be checked intermittently to ensure copying. uploading and downloading process are not interrupted.

Video Issue	Description of Problem	Resolution	Recommendations	Comments
Potential loss of video resolution	Video resolution can be degraded during uploading, downloading, and/or copying process. It can also appear to be reduced when viewing it from an external HD rather than from a high-powered computer.	Be sure and maintain HD quality and resolution when copying, downloading and uploading. View video from a high-powered laptop rather than an external HD as the latter modes cause video to appear grainy and shaky when in fact it is not.	See column three	
File names/dates /times	Identification of video segments was initially problematic. Dates and times did not always match with the signature from the video recorder. Time stamp on video was lost when opened in any software other than the original video camera format (e.g., Canon or Sony).l	a. Considerable effort and time was needed to decipher date/time stamps of video by back tracking to clips that could be identified and then using the video counter numbers and translating them to time, from a known start time. b. On 3 April 2011 we found (online) software developed by an independent person to display the time and date on video downloaded via the USB cable to the computer/external hard drives as long as the video is downloaded in the original proprietary format (e.g., Cannon). The issue that date and time are not displayed on downloaded video when not using the Cannon or Sony proprietary software AND the AV cable has been a problem for many users of the Sony video as indicated by customer complaints online. This independent software (vATS, http://dts8888.com/vATS/vats.htm) is available for purchase online for 40$ and allows display of time and date for video downloaded with USB cable, again as long as the video is downloaded in the original Sony format. It can then be opened and edited on most readily available software (e.g., windows media player, Adobe Premiere, etc.).	Run the original video through the independent software designed to allow transfer of original time and date into formats other than the original, proprietary video camera format. Alternatively, a single, dedicated stop watch can be started at the first video segment. The start time should be recorded from a GPS unit or cell phone (updated by satellite) when the stop watch is activated. At the start and end of each video segment the stop watch can be videotaped. Times can be deduced by adding the running time on the stop watch to the initial start time.	Application of the independent software that can read and display the original video camera date and time has solved previous issues. All video have subsequently been run through this program and original times and dates are now displayed on the video.

Video Issue	Description of Problem	Resolution	Recommendations	Comments
Still shots	Video is often blurred when a still shot is desired.	Alternating to a program allowing frame by frame capture.	Software specific to the video recording unit may have this option. Alternating to another program is time-consuming and should be available on software specific to the video unit of an upgrade.	
Frame by frame viewing	Frame-by-frame viewing is desirable to analyze behaviors but is not possible on all video-viewing software. This enables the viewer to examine the position of all individuals and the external environment	Using a video viewing program that has an option to view frame by frame (e.g. QuickTime Player).	Software specific to the video recorder is likely to allow frame-by-frame viewing. It may be necessary to purchase an upgrade depending on the model/brand of video recorder. However, using the original format program of the video camera means no one can see the video except people who have the proprietary software that comes with the video camera.	Frame-by-frame is valuable for analyzing behaviors in video clips. Cetaceans often react quickly to conspecifics, prey, and other stimuli. Identifying probable source for a specific action/reaction is facilitated by advancing video frame-by-frame.
Instability of recorder during video capture	Video is difficult to analyze due to shaking during recording.	An internal-stabilizer during video clips reduced some of the shaking during recordings. Using a chest monopod with the video camera attached to it with the base braced against the videographer's chest helped to reduce shakiness. However, shakiness due to air turbulence is difficult to remedy.	Chest stabilizers should be available during all surveys for all videographers	Need to investigate the cost of a more expensive and better gyrostabilizer for the camera as done by National Geographic. Consult Dr. Bernd Würsig.

Video Issue	Description of Problem	Resolution	Recommendations	Comments
Species Identification	Distance, activity or angle sometimes makes it difficult to confirm species identification during analysis for small delphinids.	Consulted with the crew on the survey for identification or made a presumptive ID. Reviewers can reference the master data sheets (electronic format in Egnyte) to determine the species.	Voice recording is obstructed by the noise of the aircraft. A means of recording an ID on the video should be visual. A piece of paper with a print out of common species names in bold print can be posted on the aircraft near the window or other location close to the videographer. ID can be established by video recording the name of the species during the clip. More than one species can be indicated by video recording more than one ID from the paper for several seconds.	Separate voice recorders were not clear enough to understand the voice of the person speaking. The separate voice recordings need to be matched up after the survey. Video recording the species ID from a piece of paper ensures correct ID matched to the correct clip without additional investment in time retrieving separate audio files.
	Voices on video or voice recorders sometimes obstructed by the aircraft noise.			
Clips extended past behaviors	Videographer continues to film after whales dive or aircraft leaves the area (either by filming the water or setting the recorder down inside the aircraft) extends the length of the video and the length of time invested in analysis while the reviewer anticipates more video of animals.	Since summer 2010 we have been stopping the video recordings when animals are not in view to minimize the size of the video file and the analysis time.	Refer to last entry : "aircraft noise: general"	Initially all video between animal surfacing was recorded as a back up to capture vocal notes by the observers for additional information.

Video Issue	Description of Problem	Resolution	Recommendations	Comments
Aircraft noise: general	Electrical interference (i.e., impedance) from aircraft sound system with video recording system caused static and high-pitched noise that interfered with ability to decipher audio on video. Wind noise from window opened to collect video sometimes interfered with ability to understand audio on video.	Aircraft noise mismatched impedance noise interference with vocals recorded through aircraft headset jacks have been replaced by placing a mini microphone in one side of an observer's aircraft headset that is then connected directly to adapter splitter into the video microphone port/jack and the voice recorder port/jack. This has resulted in crisp clear vocal recordings with no extra noise or impedance interference. This was started in Feb 2011 after trying a number of impedance-canceling cables with minimal improvement.	Resolved for electrical interference. To minimize or avoid noise interference from open window, put mini-microphone in ear of someone other than the video recorder.	Prior to this a specialized impedance cable had been purchased to try and filter out the aircraft interference noise. That reduced the noise but did not eliminate it. This problem has been solved.
Video lost when Mac and PC hardware and software used same external HD.	The 3 versions of the July 2009 video became inaccessible. Video from this survey was first downloaded to an Apple computer. It was then copied onto two external HD that we were told were interchangeable between Apple and PC computers. They were originally viewed and transcribed for the first initial view for summarizing general content and length from the external HD on a Mac. When the external HD was later opened by two separate users independently using a PC, the HD became unreadable.	One of the external HDs was brought to two different computer repair stores in Anchorage and they said they could not retrieve the data. The second external HD was taken to 3 different computer repair stores in the Seattle area and they also were not able to retrieve the video. More research was done on expert data retrieval services. One external HD was then sent to such a service but the retrieval fee was 1600$ initially so further investigation was ceased due to cost and no guarantee of retrieval. Another smaller expert data retrieval company was then contacted and the two HDs were sent to this company. They quoted a minimum cost of 900$ possibly more. The HDs are currently being examined by this group. However, they take about 1 one month to conduct the assessment.	Do not interchange use of Apple and PC computers when copying and viewing data. Make 4 copies of the video including an online offsite copy.	All videos have since been uploaded to an offsite online data storage site and copied to 3 external HDs located in different regions. We are using only PCs and PC software for video analyses, review and transcription.

APPENDIX C. Passive Acoustic Monitoring Reports for Scripps Institute of Oceanography High-frequency Acoustic Recording Packages within the Southern California Range Complex

Marine Physical Laboratory of the Scripps Institution of Oceanography University of California, San Diego

SCRIPPS Whale Acoustics

Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training Area 2010-2011

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Photo by Michael H. Smith

MPL TECHNICAL MEMORANDUM # 531

EXECUTIVE SUMMARY

Passive acoustic monitoring was conducted at two sites in the Navy's Southern California Range Complex during April 2010 – April 2011. These data provide information on the presence of marine mammals and anthropogenic sound sources. High-frequency acoustic recording packages documented sounds between 10 Hz and 100 kHz with nearly continuous temporal coverage at a site near Santa Barbara Island (site M) and a site south of San Clemente Island (site N). For this reporting period, 8,099 hours of acoustic recordings were obtained from site M and 7,779 hours of recordings from site N. Data analysis methods consisted of analyst scans of long-term spectral averages and spectrograms. The data were divided into three frequency bands and each band was analyzed for the sounds of marine mammal species or anthropogenic sources. Representative sounds are presented.

Six baleen whale species were recorded: blue whales, fin whales, Bryde's whales, gray whales, humpback whales, and minke whales. Site N has more calling baleen whales than site M, as blue, fin, humpback, and Bryde's whale calls were all detected during more hours at site N. However, gray whale calls were detected only at site M. Pinniped barks, presumably made by California sea lions, were recorded during just a single week and only at site M. The largest number of odontocete detections by echolocation clicks and whistles were attributed to "unidentified dolphin" which is primarily comprised of short- and long-beaked common dolphins as well as bottlenose dolphins. Unidentified dolphins were detected throughout the year with a peak acoustic activity in late summer and fall months. Overall numbers of detections were slightly higher at site N than M. There was a distinct diel acoustic activity likely due to nighttime foraging, which was more apparent for click and less for whistle detections. Risso's dolphin echolocation clicks occurred throughout the year with increased detections in winter and early spring at site M. They were generally more frequent at site M than N. Two kinds of Pacific white-sided dolphin echolocation clicks were detected: Type A were present more often at site N and with higher numbers of detections at night indicating nighttime foraging, whereas type B were overall very seldom with highest detections at site M and a higher rate of detections during daytime. Sperm whale echolocation clicks were distributed throughout the year with more frequent detections at site M. Cuvier's beaked whales were detected throughout the year at both sites with higher numbers of occurrences at site N. A few detections were made of Baird's beaked whale and Stejneger's beaked whale, as well as two unidentified beaked whales with peak echolocation signal frequencies at 43 kHz and 50 kHz.

Ship noise was the most common anthropogenic noise at both sites M and N. Both sites had Mid-Frequency Active (MFA) sonar events throughout the period April 2010 – April 2011. At site N, over 55,000 MFA sonar pings were detected ranging from 105 to 170 dB pp re 1 μPa. While site M had MFA sonar events recorded, the received levels and the number of pings were often much lower (e.g. < 120 dB pp re 1 μPa and 10's of pings/event) than at site N. Echosounder pings with a variety of primary frequencies (8 – 80 kHz) were found at both sites M and N. More echosounders were present at site M than at site N. Explosions were recorded at both sites up to 40 hours per week.

PROJECT BACKGROUND

The Navy's Southern California Offshore Range (SCORE) is located in the California Borderlands and adjacent deep water to the west (Figure 1). This region has a highly productive marine ecosystem owing to the southward flowing California Current, and associated coastal current system. A diverse array of marine mammals is found in this region, including baleen whales, beaked whales and other cetaceans and pinnipeds.

In January 2009, an acoustic monitoring effort was initiated within the boundaries of SCORE with support from the Pacific Fleet under contract to the Naval Post-Graduate School (DoN 2009). The goal of this effort was to characterize the vocalizations of marine mammal species present in the area, to determine their year-round seasonal presence, and to evaluate the potential for impact from Naval operations. This report documents the analysis of two High-frequency Acoustic Recording Packages (HARPs) that have been deployed within SCORE, one to the southwest and one to the northwest of San Clemente Island (Figure 1) during the time period April 2010 – April 2011.

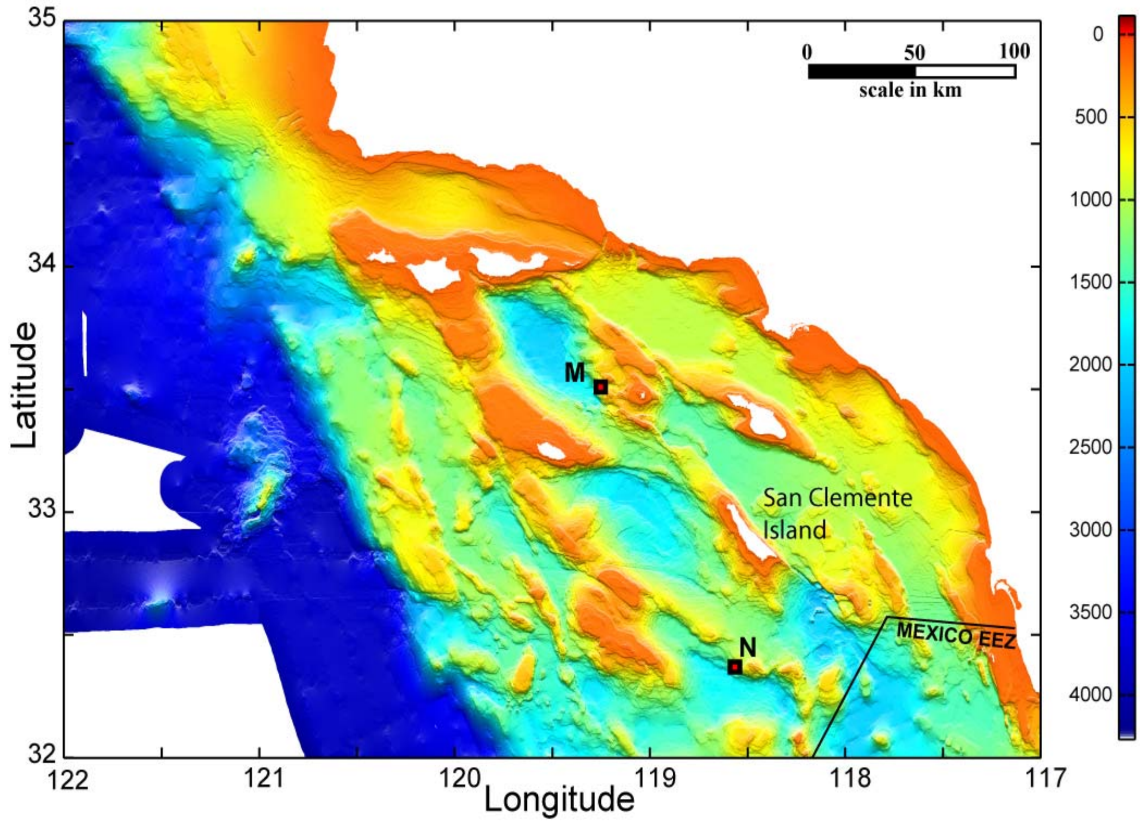

Figure 1. Locations of High-frequency Acoustic Recording Packages at sites M and N in the southern California Range Complex area. Color is bathymetric depth (scale bar at right in meters depth).

METHODS

High Frequency Acoustic Recording Packages

High-frequency Acoustic Recording Packages (HARPs) were used to detect marine mammal species and characterize ambient noise in the SOCAL Naval Training area. HARPs record underwater sounds from 10 Hz to 100 kHz with approximately 110 days of continuous data storage. The HARP sensor and mooring package are described in Wiggins and Hildebrand (2007). For the SOCAL range deployments, the HARP was located on the seafloor with the hydrophone suspended 10 m above. Each HARP is calibrated in the laboratory to provide a quantitative analysis of the received sound field. Representative data loggers and hydrophones have also been calibrated at the Navy's TRANSDEC facility to verify the laboratory calibrations.

Data Collected to Date

Acoustic data have been collected at two sites within SCORE using autonomous High-frequency Acoustic Recording Packages (HARPs) sampling at 200 kHz since January 2009 (Table 1). The two sites are designated site M (33° 30.92N, 119° 14.96W, depth 920 m) and site N (32° 22.18N, 118° 33.77W, depth 1250 m).

Table 1. SCORE acoustic monitoring since January 2009. Period of instrument deployment analyzed in this report is shown in bold. Results of acoustic monitoring through April 2010 are described in Hildebrand et al. (2009, 2010a and 2010b).

Deployment Designation	Site M Deployment Period	Site N Deployment Period
SOCAL 31	1/13/09 - 3/10/09	1/13/09 - 3/13/09
SOCAL 32	3/10/09 - 5/16/09	3/14/09 - 5/19/09
SOCAL 33	5/16/09 – 7/26/09	5/19/09 – 7/22/09
SOCAL 34	7/27/09 – 9/25/09	7/22/09 – 9/25/09
SOCAL 35	9/25/09 – 12/4/09	9/25/09 – 12/6/09
SOCAL 36	12/4/09 – 1/29/10	12/6/09 – 1/30/10
SOCAL 37	1/29/10 – 4/9/10	1/30/10 – 4/11/10
SOCAL 38	4/9/10 – 7/21/10	4/11/10 – 7/23/10
SOCAL 40	7/21/10 – 12/5/10	7/23/10 – 12/6/10
SOCAL 41	12/5/10 – 5/10/11	12/6/10 – 5/12/11

DATA ANALYSIS

To assess the quality of the acoustic data, frequency spectra were calculated for all the data (over one-year at each of two instruments) using a time average of 5 seconds and frequency bins of 1 Hz. These data, called Long-Term Spectral Averages (LTSA) were then examined both for characteristics of ambient noise and also as a means to discover marine mammal and anthropogenic sounds in the data set.

Recording a broad frequency range up to 100 kHz allows detection of baleen whales (mysticetes), toothed whales (odontocetes) and seal/sea lion (pinniped) species. The presence of acoustic signals from multiple marine mammal species was analyzed, along with the presence of anthropogenic noise such as sonar, explosions, and shipping. All data were analyzed by visually scrutinizing LTSAs in appropriate frequency bands. When a sound of interest was identified in the LTSA, we often examined the waveform or spectrogram at the time of interest to further identify particular sounds to species or source. Acoustic classification was carried out either from comparison to species-specific spectral characteristics or through analysis of the time and frequency characters of individual sounds.

To document the data analysis process, we describe the major classes of marine mammal calls and anthropogenic sounds in the SOCAL region, and the procedures used to detect them in the HARP data. For effective analysis, the data were divided into three frequency bands and each band was analyzed for the sounds of an appropriate subset of species or sources. The three frequency bands are as follows: (1) low frequencies, between 10 – 1000 Hz, (2) mid frequencies, between 500 – 5000 Hz, and (3) high frequencies, between 1 – 100 kHz. Blue, fin, Brydes's, and grey whale sounds were classified as low frequency; humpback, minke, pinnipeds, shipping, explosions, and mid-frequency active sonar were classified as mid-frequency; while the remaining odontocete and sonar sounds were considered high-frequency. We describe the calls and procedures separately for each frequency band.

Low Frequency Marine Mammals

For the low frequency data analysis, the 200 kHz sampled raw-data are decimated by a factor of 100 for an effective bandwidth of 1 kHz. Long-term spectral averages (LTSAs) of these data are created using a time average of 5 seconds and frequency bins of 1 Hz. The presence or absence of each call type was determined in hourly bins for each low frequency dataset.

Blue whale A, B and D calls, fin whale 20 Hz pulses, and Bryde's whale Be4 calls were monitored for this report, in addition to gray whale calls and the "50 Hz pulse" call type of unknown origin (presumably baleen whale). A low frequency rapid pulsing sound (presumably from fish) is also described as it occasionally masked baleen whale sounds. The same LTSA and spectrogram parameters were used to detect all call types. For spectrogram scrolling, the LTSA frequency was set to display between 1-500 Hz. To observe individual calls, spectrogram parameters were typically set to 120 seconds by 200 Hz. The FFT was generally set between 1500 and 2000 data points (yielding about 1 Hz frequency resolution), with an 85-95% overlap of data in the input time series. Table 2 presents a quantitative description of each call type.

Blue Whales

Several different calls were used to detect the presence of blue whales in the dataset. Calls of type A and B (Figure 2) are representative of the blue whale population found in the eastern North Pacific (McDonald et al. 2006) and are produced exclusively by males and likely associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 sec) and low frequencies (10-100 Hz) that can be produced either as repetitive sequences (song) or as singular calls. The A call is pulsed, whereas the B call has a set of harmonic tonals. Individual A and B calls are readily detected in an LTSA, owing to their long duration (Figure 2). For this report manual scanning of the LTSA has been the primary means for blue whale call detection.

Table 2: Description of selected low frequency whale calls in SOCAL HARP data. The mean values (±one standard deviation) of measurements from 30 independent calls are presented. Measured calls were separated by a minimum of 24 hours to try to ensure calls from a single animal are not over-represented.

Species	Call Type	Start Frequency (Hz)	End Frequency (Hz)	Duration (s)
Blue whale	B	48.6 (± 0.9)	44.3 (± 0.7)	12.2 (± 1.5)
	D	72.5 (± 11.6)	32.3 (± 8.2)	3.3 (± 1.6)
Fin whale	20 Hz pulse	31.6 (± 2.3)	18.7 (± 1.4)	1.1 (± 0.2)
Unidentified	50 Hz pulse	62.6 (± 5.7)	46.5 (± 5.5)	0.6 (± 0.1)
Bryde's whale	Be4	52.9 (± 1.5)	58.1 (± 0.6)	1.9 (± 0.3)

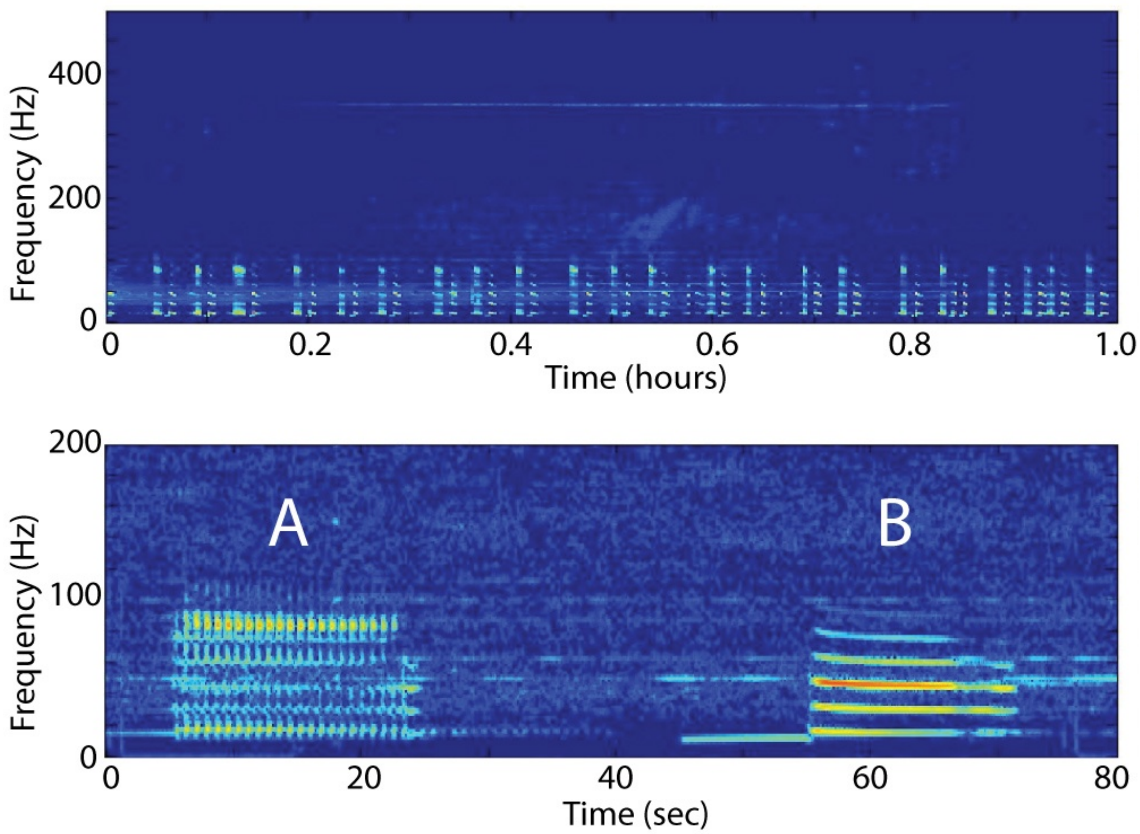

Figure 2. Long term spectral average (above) and spectrogram (below) of blue whale A and B calls (spectrogram made with 1200-point FFT and 80% overlap).

Since blue whale calls are low frequency, they occupy the same band as noise generated by shipping, as well as sounds thought to be produced by fish (Figure 3). These anthropogenic and biological sounds make it challenging to detect blue whale calls, affecting the ability of both analysts and computer algorithms to find calls imbedded in noise. Likewise, there are regular sounds introduced into the HARP data on a 75 sec interval that are associated with the noise of the mechanical spinning of the disk drive, appearing in the LTSA as a regular series of sounds.

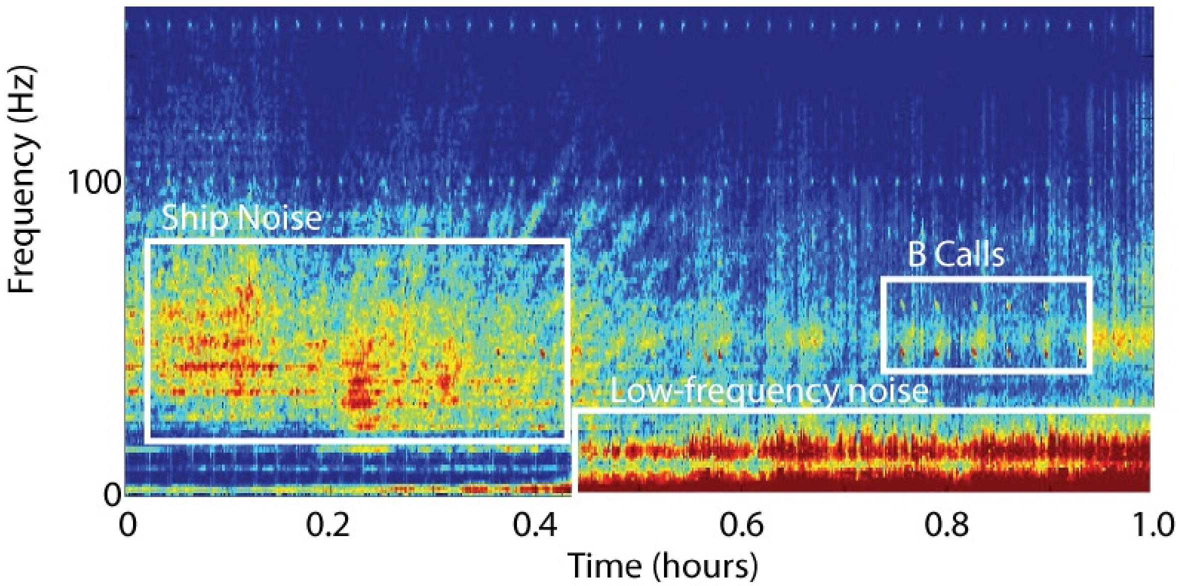

Figure 3. LTSA with blue whale B calls in the presence of ship noise and low frequency rapid-pulsing noise (thought to be produced by fish).

Blue whale B calls are long duration tonals that are harmonically related and slightly downswept in frequency. Owing to greater noise at low frequency, B calls are best identified based on the presence of their 3rd harmonic at 46 Hz, which generally has a higher signal to noise ratio (SNR) than the fundamental frequency at 15 Hz. B calls occasionally exhibit two segments, with a break or step in the frequency of the tonal in the latter portion of the call (Figure 4).

Blue whale D calls are down-swept in frequency (100-40 Hz) with a duration of several seconds (Figure 5). These calls are similar worldwide and are associated with feeding animals; they may be produced as call-counter call between multiple animals (Oleson et al. 2007a). In the SOCAL region, D calls are produced in highest numbers during the late spring and early summer, and in diminished numbers during the fall, when A-B song dominates blue whale calling (Oleson et al. 2007b).

Fin Whales

Fin whales are known to produce pulsed calls with about 1 sec duration, that are downswept in the frequency band 30 - 15 Hz (Figure 6). These pulses occur both at regular intervals as song (Thompson et al. 1992), and at somewhat irregular intervals as counter-calling between multiple animals (McDonald et al. 1995). Fin whale 20 Hz pulses appear as a band of energy in the LTSA (Figure 7). For the purposes of this report we indicate the presence of 20 Hz pulses, but we do not attempt to categorize them as either song or irregular interval calls.

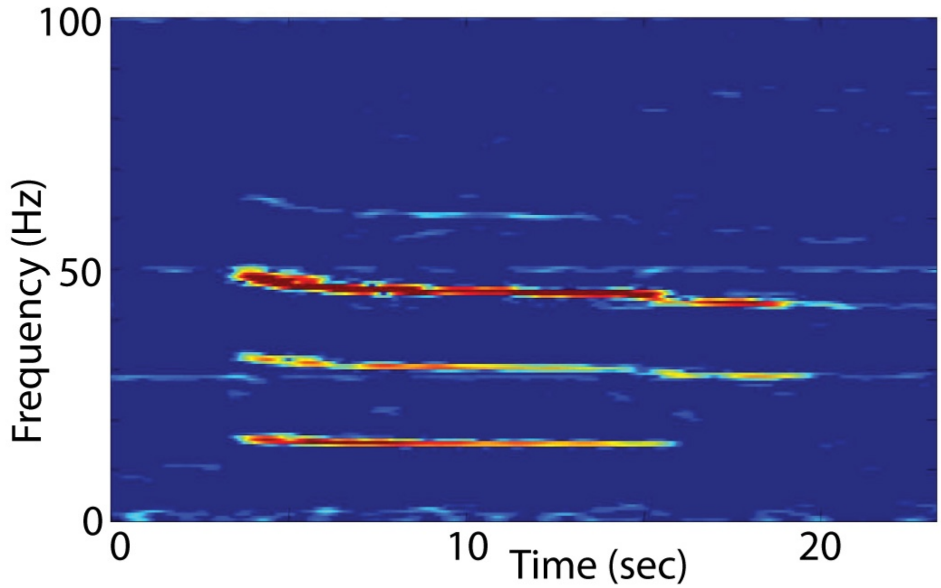

Figure 4. Blue whale B call showing harmonic tones with frequency step near the end of the call (FFT 3500 points, 98% overlap).

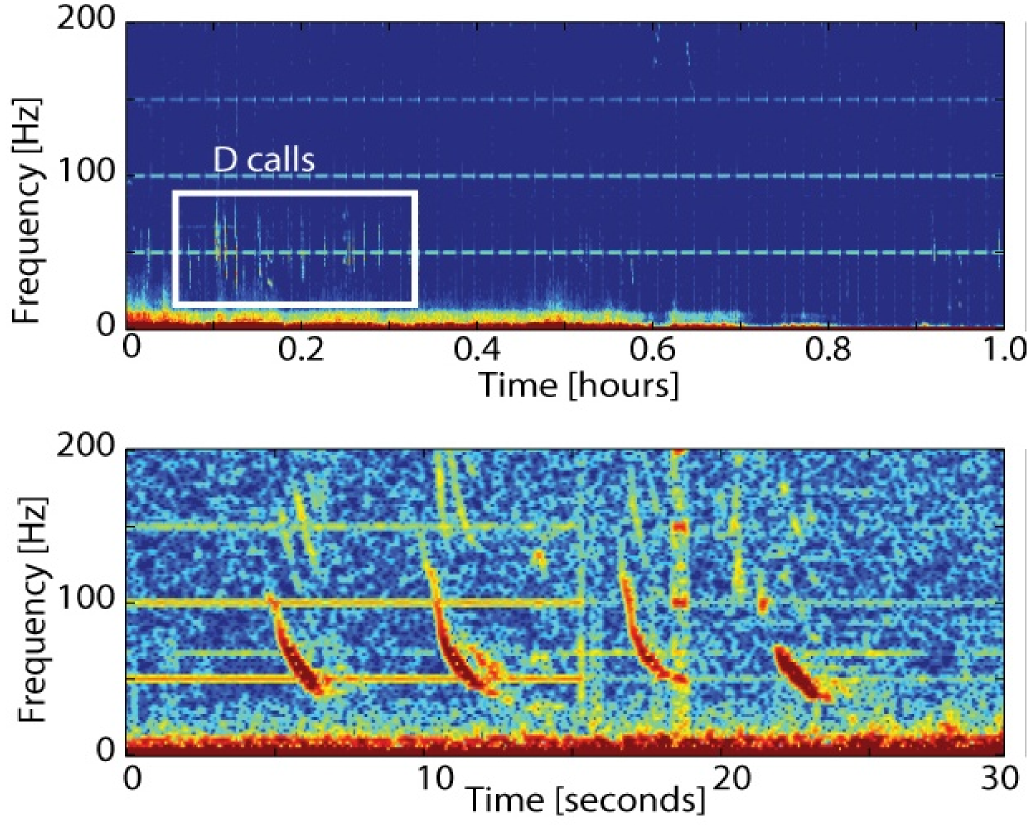

Figure 5.21 LTSA (above) with a red box marking the period of blue whale D calls enlarged in the spectrogram (below), (1000-point FFT and 90% overlap).

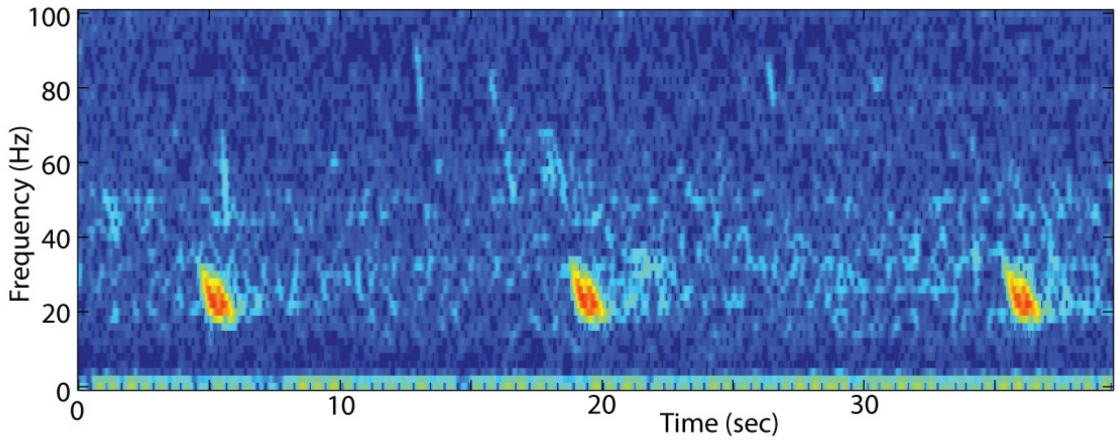

Figure 6. Fin whale 20 Hz pulsed call, created in regular pattern or song.

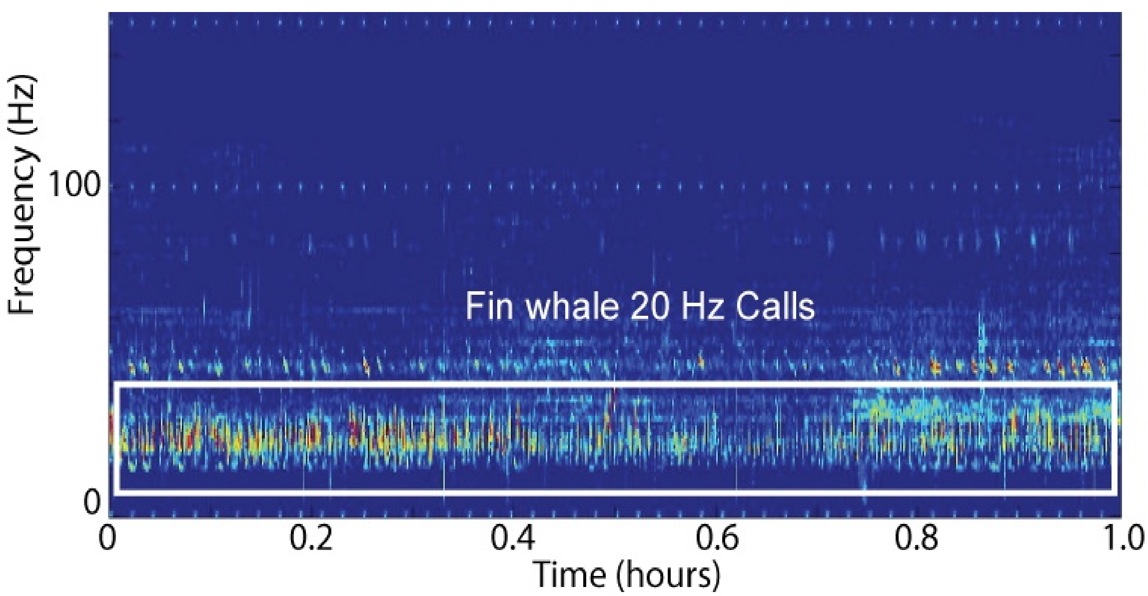

Figure 7. LTSA with fin whale 20 Hz pulsed calls (as well as blue whale B and D calls).

"50 Hz" Whales

Another low frequency call detected in the SOCAL data is a downswept pulse from 75 – 40 Hz; we will designate these as "50 Hz" calls (Figure 8 for spectrogram and Figure 9 for LTSA). The 50 Hz calls were first described by Watkins (1981) as associated with fin whales, but they have not been reported in the literature since. For this report manual scanning of the LTSA and subsequent verification from a spectrogram have been the primary means for 50 Hz call detection.

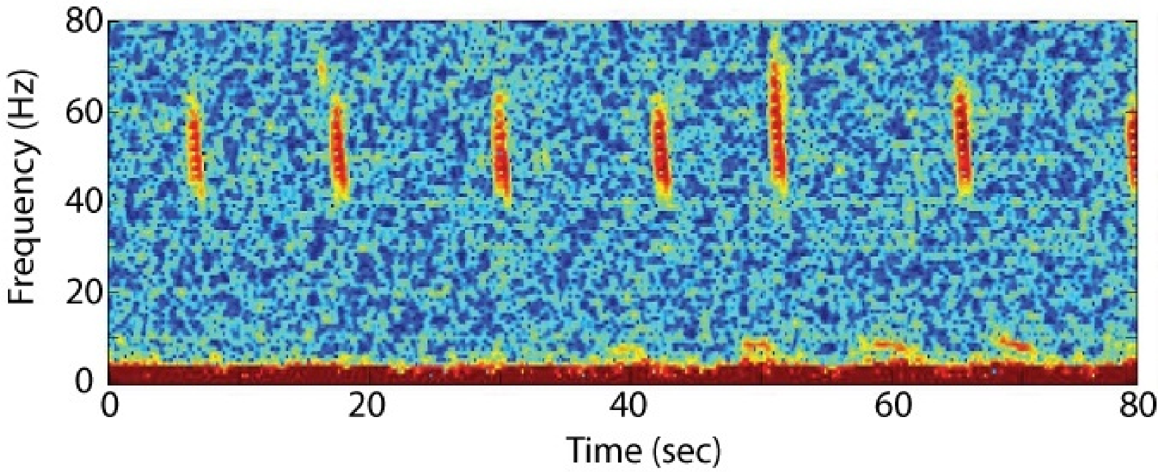

Figure 8. The 50 Hz pulse that has been associated with fin whales (Watkins 1981).

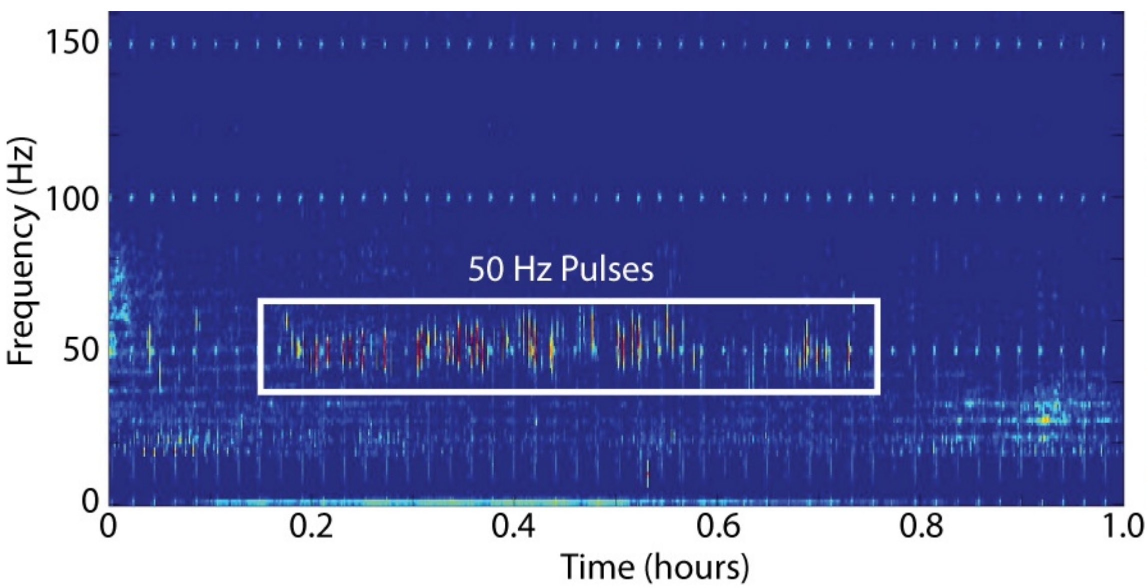

Figure 9. LTSA of the 50 Hz pulse associated with fin whales.

Bryde's Whales

Bryde's whales generally inhabit the warm waters of the eastern tropical Pacific and the Gulf of California, Mexico (Leatherwood et al., 1988; Tershy et al., 1991). The SOCAL region is considered their northerly range limit, although they have been sighted occasionally farther north (Barlow & Forney, 2007). The Be4 call is one of several call types (Oleson et al. 2003) in the Bryde's whale repertoire. Be4 calls are the most common Bryde's whale call observed in the SOCAL region. The Be4 call consists of a short, slightly upswept tone between 50 – 60 Hz. The call occasionally has harmonics and overtones present, along with an undertone that follows the primary tone (Figure 10 and Figure 11). The Be4 call is typically observed at regular intervals; occasionally, it is evident that multiple callers are present.

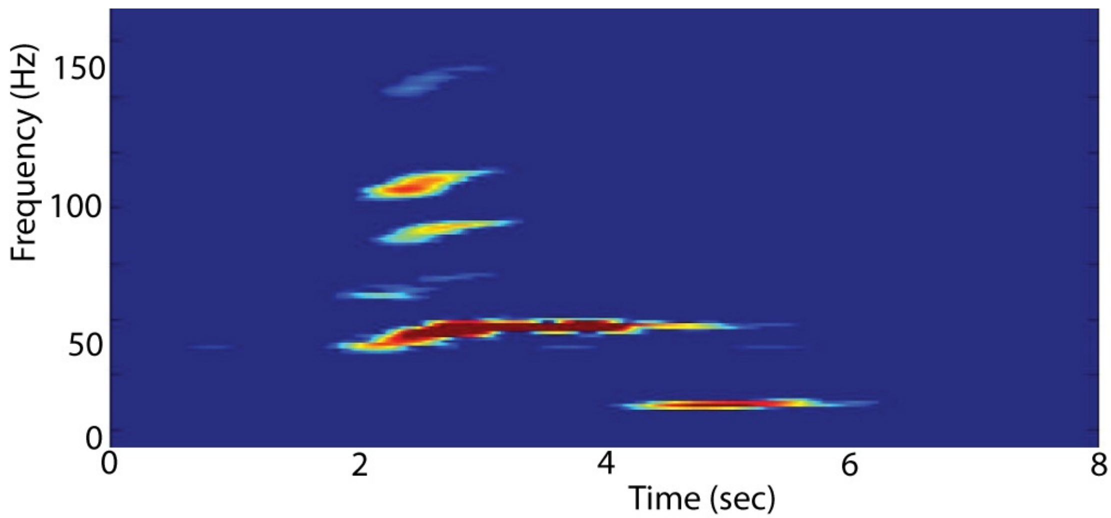

Figure 10. Spectrogram of Bryde's whale Be4 call type.

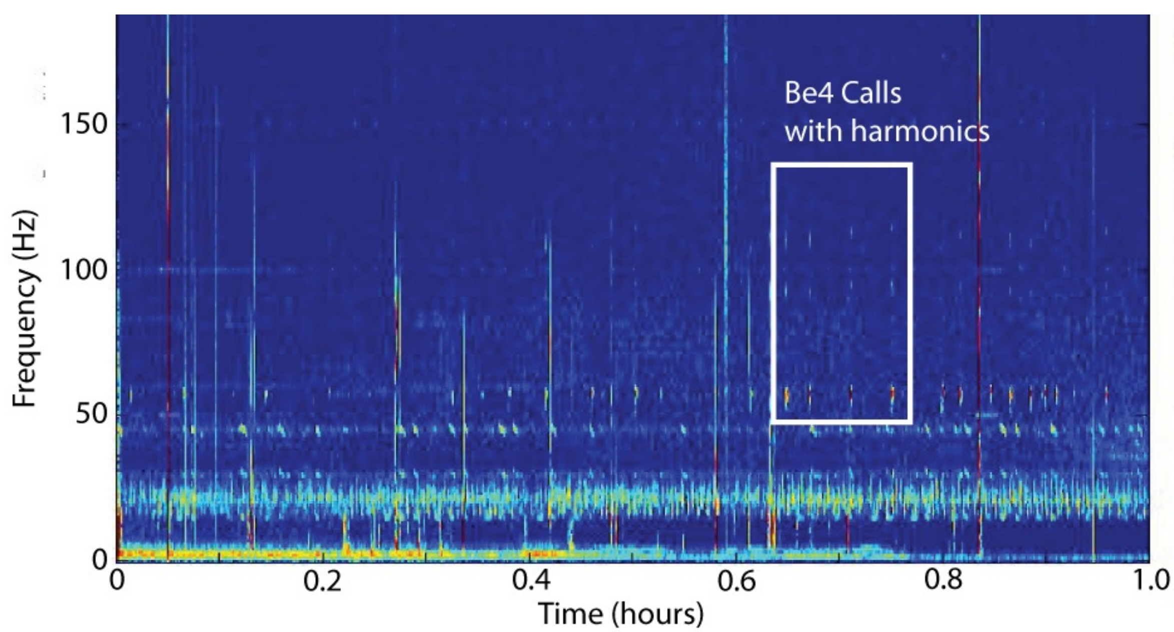

Figure 11. LTSA with Bryde's whale Be4 call type at 60 Hz with overtones.

Gray Whales

Gray whales produce low frequency sounds along their migration route between Baja California and the Bering Sea. Four types of sounds have been described (Crane and Lashkari 1996): M1 were pulses and bonging signals, M3 were low frequency moans, M4 were grunts, and M5 were subsurface exhalations. M3 signals are known to be the most common (Figure 12), followed by M1 signals (Figure 13). Both signal types can be discerned from the LTSA and are reported jointly in this report.

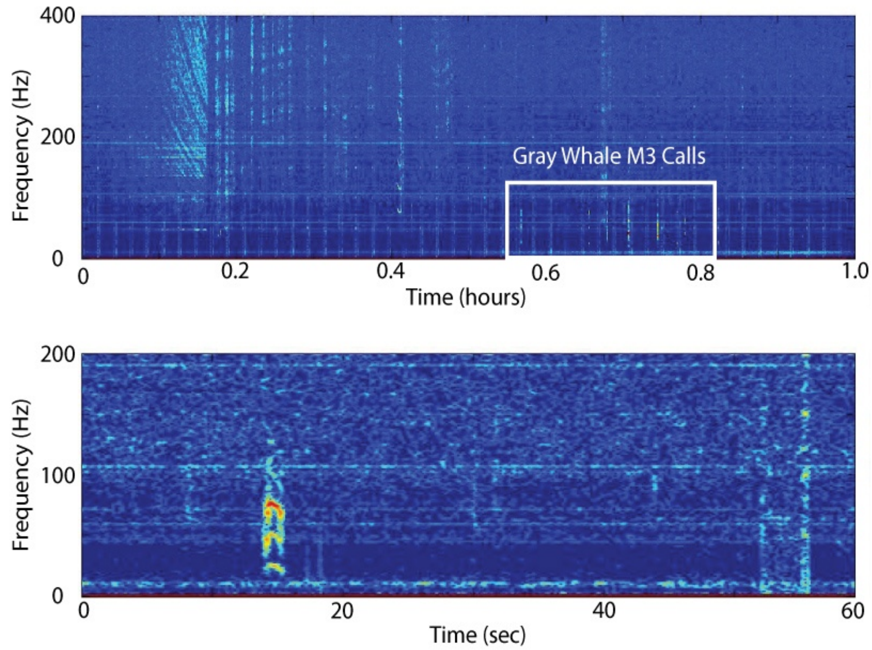

Figure 12. LTSA and spectrogram of gray whale M3 calls.

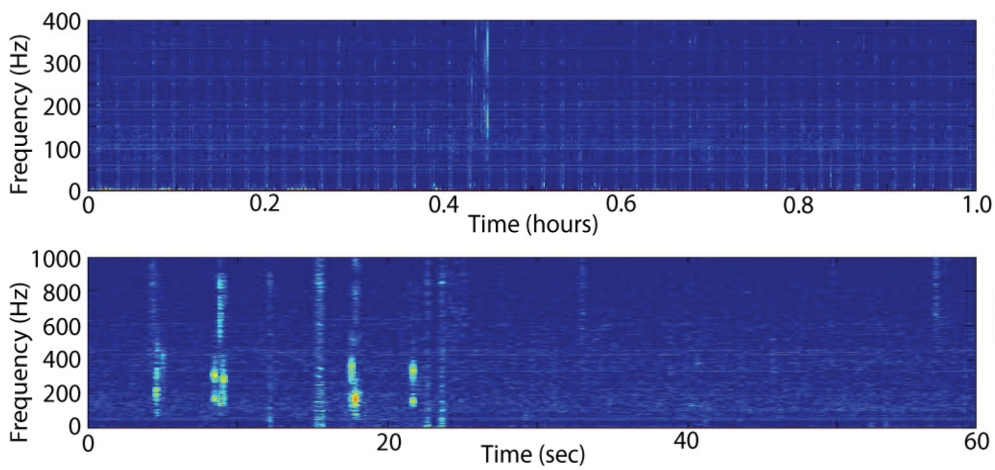

Figure 13. LTSA and spectrogram of gray whale M1 calls.

Mid-Frequency Marine Mammals

For mid-frequency data analysis, the raw 200 kHz HARP data were decimated by a factor of 20 for an effective bandwidth of 5 kHz. The LTSAs for mid-frequency data analysis are created using a time average of 5 seconds, and a frequency bin size of 10 Hz. The presence or absence of each call type was determined in hourly bins for each mid-frequency dataset.

Mid-frequency sounds monitored in this report include: humpback whale, minke whale, pinniped, MFA (Mid-Frequency Active) sonar, explosions, and broadband ship noise. The LTSA search parameters used to detect each sound are given in Table 3.

Table 3. Mid-Frequency data analysis parameters.

Species	LTSA Search Parameters	
	Plot Length (Hr)	Frequency Range (Hz)
Humpback	0.75	150-5000
Minke	0.5	1000-2000
Pinniped	0.75	200-700
MFA Sonar	0.75	1000-5000
Broadband Ship Noise	3.0	0-5000
Explosions	0.75	0-5000

Humpback Whale

Humpback whales song is categorized by the repetition of units, phrases and themes as defined by Payne and McVay (1971). Non-song vocalizations such as social sounds and feeding sounds consist of individual units that can last from 0.15 to 2.5 seconds (see Dunlop et al 2007 and Stimpert et al 2001). Most humpback whale vocalizations are produced between 100-3000 Hz (Figure 14). For this report we detected humpback calls (both song and non-song) using a computer algorithm (Helble et al. submitted), and then verified the accuracy of the detected signals with a trained analyst.

Minke Whale

Minke whales "boings" consist of 2 parts, beginning with a burst followed by a long buzz, with the dominant signal band just below 1400 Hz (Figure 15). A typical California minke boing has an average duration of 3.6 seconds and a pulse repetition rate of 92 s-1 (Rankin and Barlow 2005).

Pinniped

Pinniped sounds in California consist mainly of barking California sea lions. Most of these vocalizations occur between 400 and 600 Hz, with short durations of less than 1 second. Pinniped vocalization bouts can occur up to several hours at a time. Often confused with humpback vocalizations in the LTSA, it is necessary to zoom in to the spectrogram view to confirm presence of pinnipeds in the data (Figure 16).

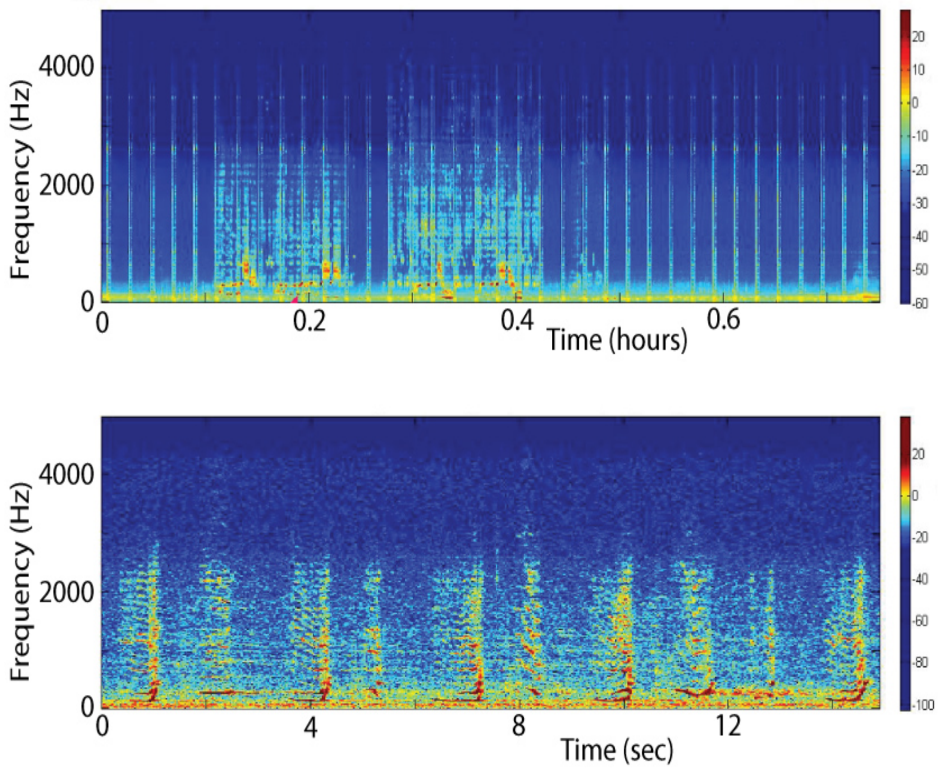

Figure 14 Humpback song in the LTSA (above) and spectrogram (below).

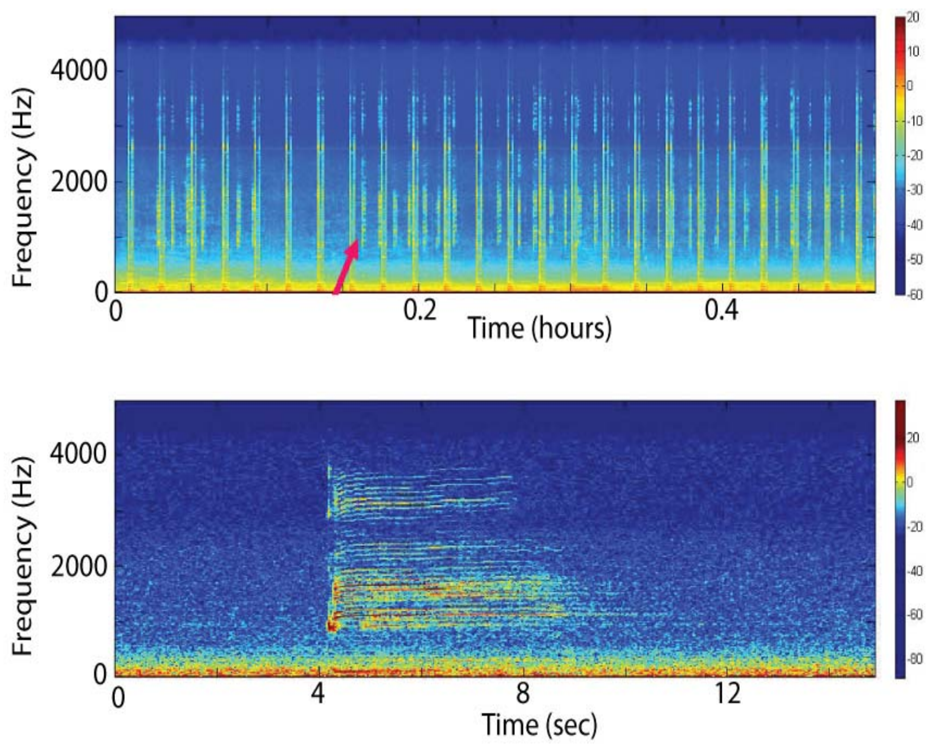

Figure 15. A series of minke boings in the LTSA (above with red arrow), with a single boing in the spectrogram (below).

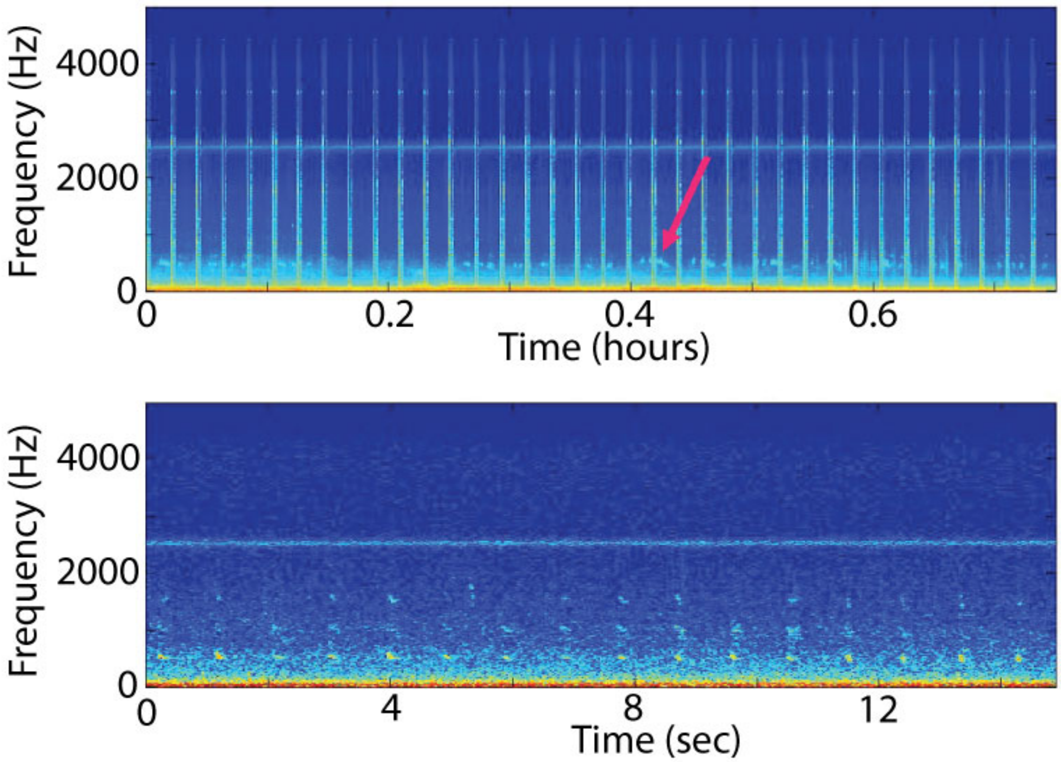

Figure 16. A bout of pinniped barks in the LTSA (red arrow in upper) and spectrogram (below).

High Frequency Marine Mammals

For the high frequency data analysis, spectra were calculated for the full effective bandwidth of 100 kHz. The LTSAs were created using a time average of 5 seconds and a frequency bin size of 100 Hz. The presence of call types was determined in one-minute bins.

Unidentified Dolphin

Delphinid sounds can be categorized as either: (1) echolocation clicks, (2) buzz pulses, or (3) whistles. Dolphin echolocation clicks are broadband impulses with the majority of energy between 20 and 60 kHz. Buzz pulses are rapidly repeated clicks that have a creak or buzz-like sound quality; they are in approximately the same frequency band as the echolocation clicks. Dolphin whistles are tonal calls predominantly between 5 and 20 kHz that vary in their degree of frequency modulation as well as duration. These signals are easily detectable in an LTSA as well as the spectrogram (Figure 17).

Some delphinid sounds are not yet distinguishable by species based on the character of their clicks, buzz pulses or whistles (Roch et al. 2007 and 2011). Both common dolphin species (short-beaked and long-beaked) and bottlenose dolphins make clicks and whistles that are thus far indistinguishable from each other (Soldevilla et al. 2008). These detections are classified as odontocete echolocation clicks in the HARP data analysis.

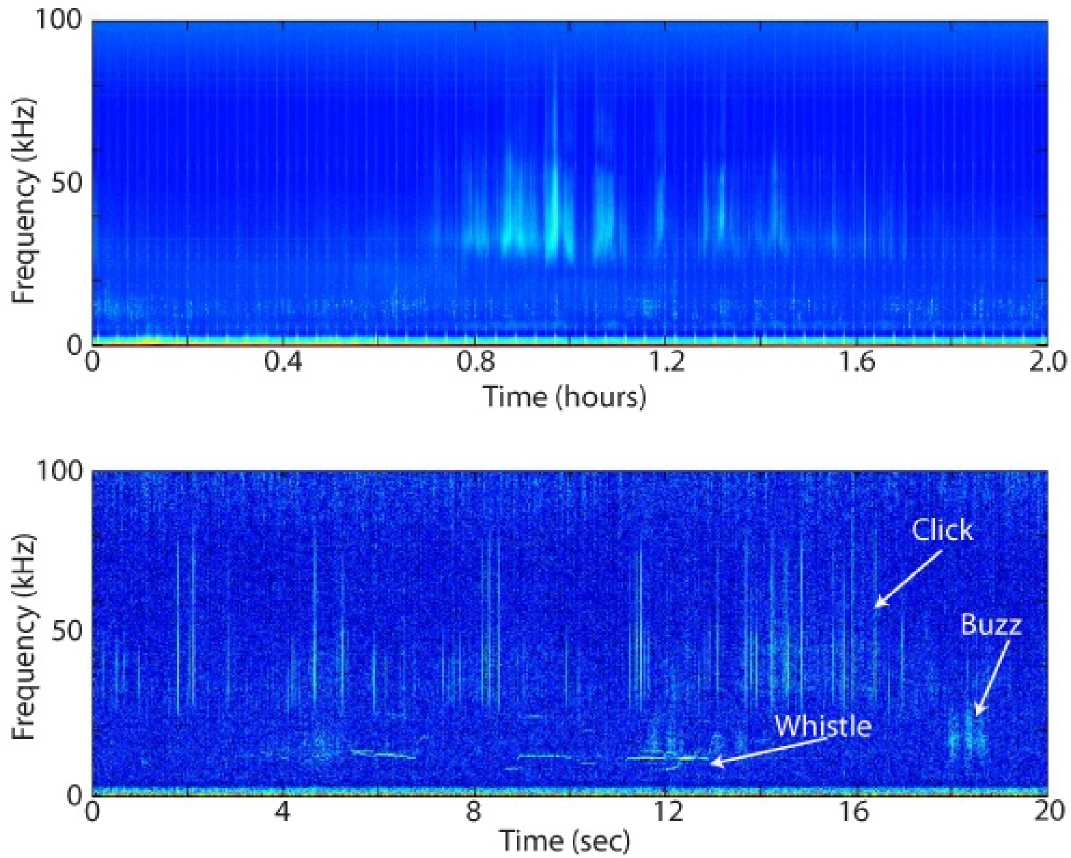

Figure 17. LTSA (top) and spectrogram of odontocete echolocation clicks and whistles (either common or bottlenose dolphins).

Risso's Dolphin

Risso's dolphin echolocation clicks can be identified to species by their distinctive banding patterns observable in the LTSA (Figure 18). Risso's dolphin echolocation clicks have energy peaks at 22, 26, 30, and 39 kHz (Soldevilla et al. 2008).

Pacific White-Sided Dolphin

Pacific white-sided dolphin echolocation clicks also can be identified to species by their distinctive banding patterns (Figure 19 and Figure 20). Pacific white-sided dolphin echolocation clicks have energy peaks at 22, 27, 33, and 37 kHz. Soldevilla et al. (2008, 2010) were able to decipher two different click types within Pacific white-sided dolphin recordings that belong to the two populations with ranges that overlap in the Southern California Bight. The two click types are distinguished by a frequency difference in the second peak. For the HARP data analysis we have specified the Pacific white-sided clicks to be either type A (Figure 19) or B (Figure 20).

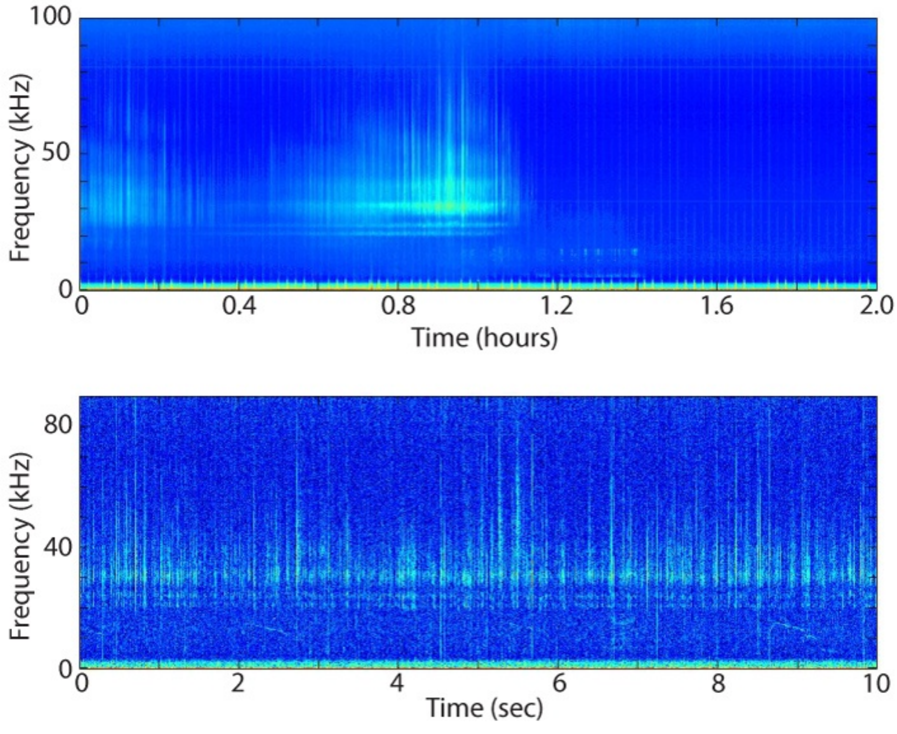

Figure 18. Risso's dolphin click bout in LTSA (above) and spectrogram (below). A distinctive banding pattern is seen in the LTSA.

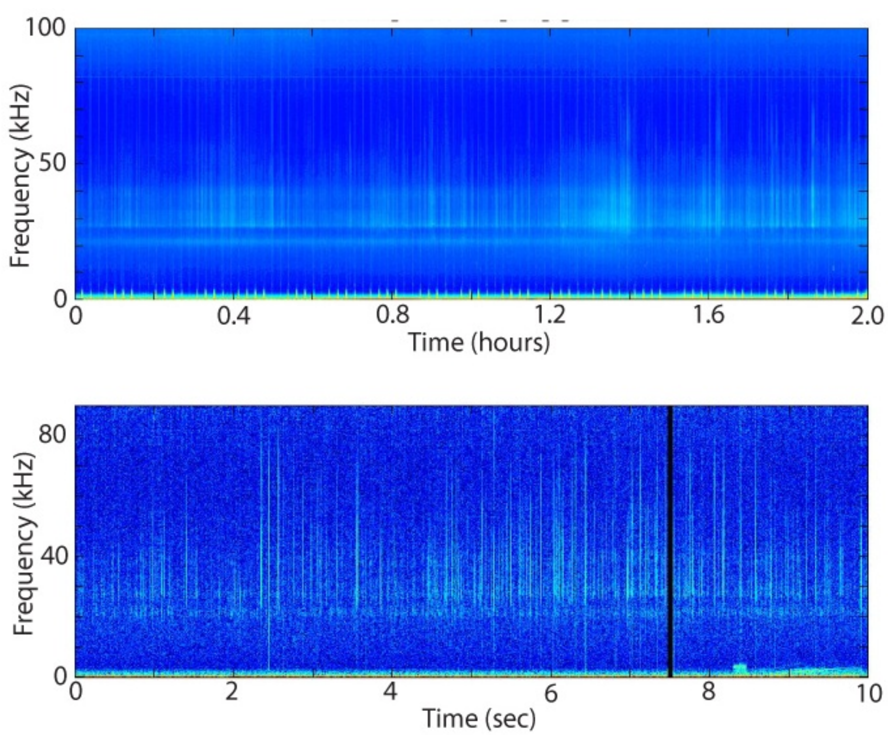

Figure 19. Pacific white-sided dolphin type A echolocation clicks in LTSA (above) and spectrogram (below).

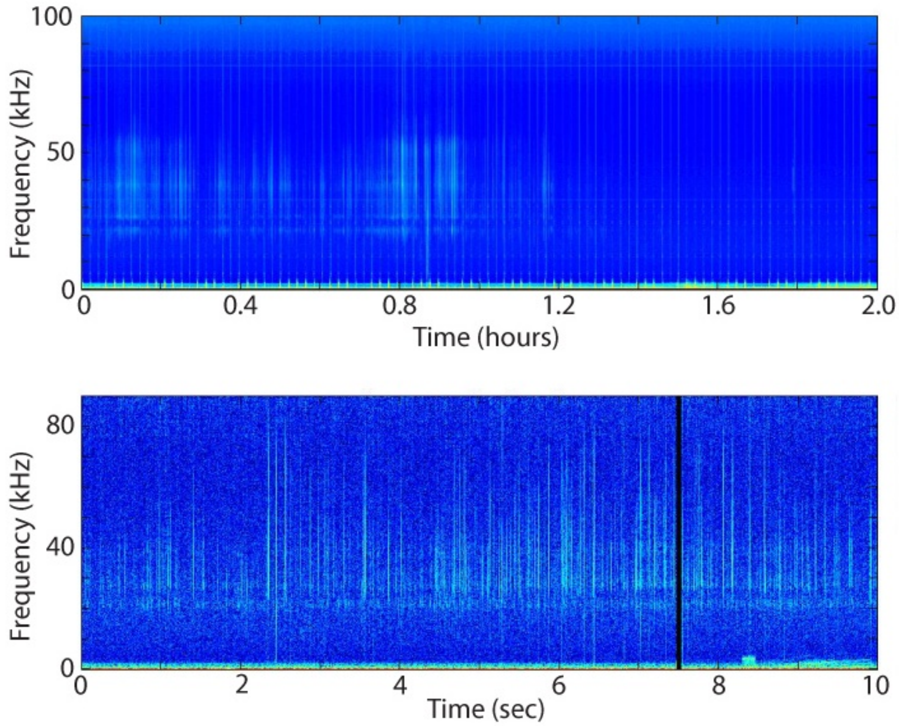

Figure 20. Pacific white-sided dolphin type B echolocation clicks in LTSA (above) and spectrogram (below).

Killer Whale

Killer whales are known to produce four call types: echolocation clicks, low frequency whistles, high-frequency (ultrasonic) whistles, and pulsed calls (Ford et al. 1989, Samarra et al. 2010). Killer whale pulsed calls are well documented and the best described of their call types. Pulsed calls' primary energy is between 1 and 6 kHz, with high frequency components occasionally >30 kHz and duration primarily between 0.5 and 1.5 seconds (Ford et al. 1989). Ultrasonic whistles have only recently been attributed to killer whales in both the Northeast Atlantic (Samarra et al. 2010) and Northeast Pacific (Simonis et al., in prep.). These whistles have fundamental frequencies between 17 and 75 kHz, the highest of any known delphinid whistles.

We do not use echolocation clicks or low frequency whistles to positively identify killer whale presence as these call-types are highly variable and not easily distinguished from other odontocete clicks and whistles (e.g. pilot whales). Instead we use the pulsed calls (Figure 21) and the ultrasonic whistles (Figure 22) for killer whale species identification. Since killer whale sightings in the SOCAL region are rare (authors' CalCOFI survey results), few acoustic detections were expected. Additionally, acoustic classification of killer whale signals is difficult due to their similarity with false killer whale and short-finned pilot whale acoustic signals.

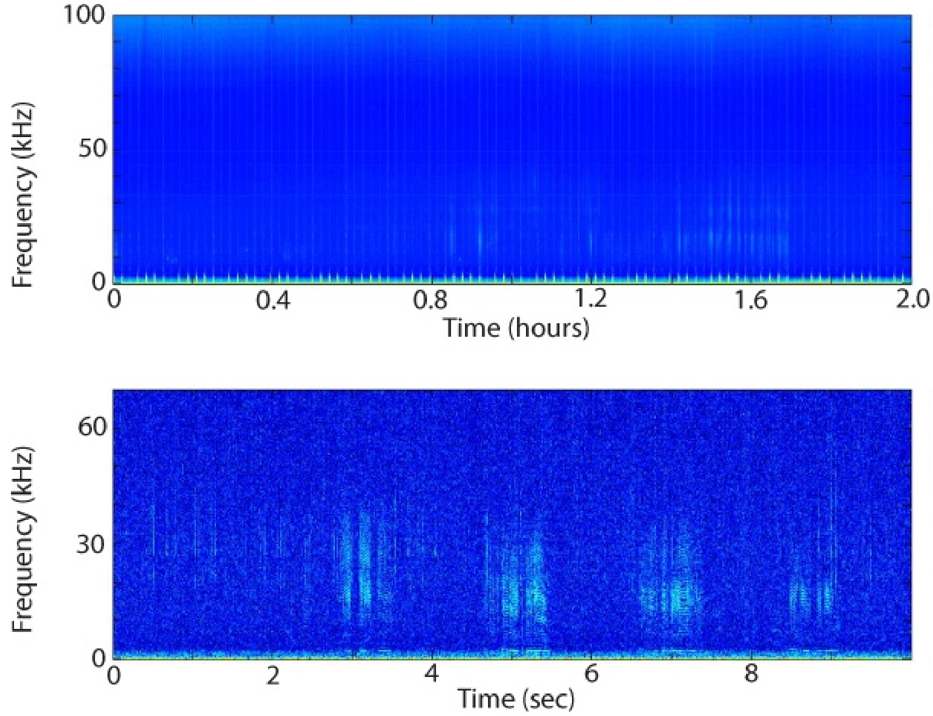

Figure 21. Killer whale pulsed calls in the LTSA (above) and spectrogram (below).

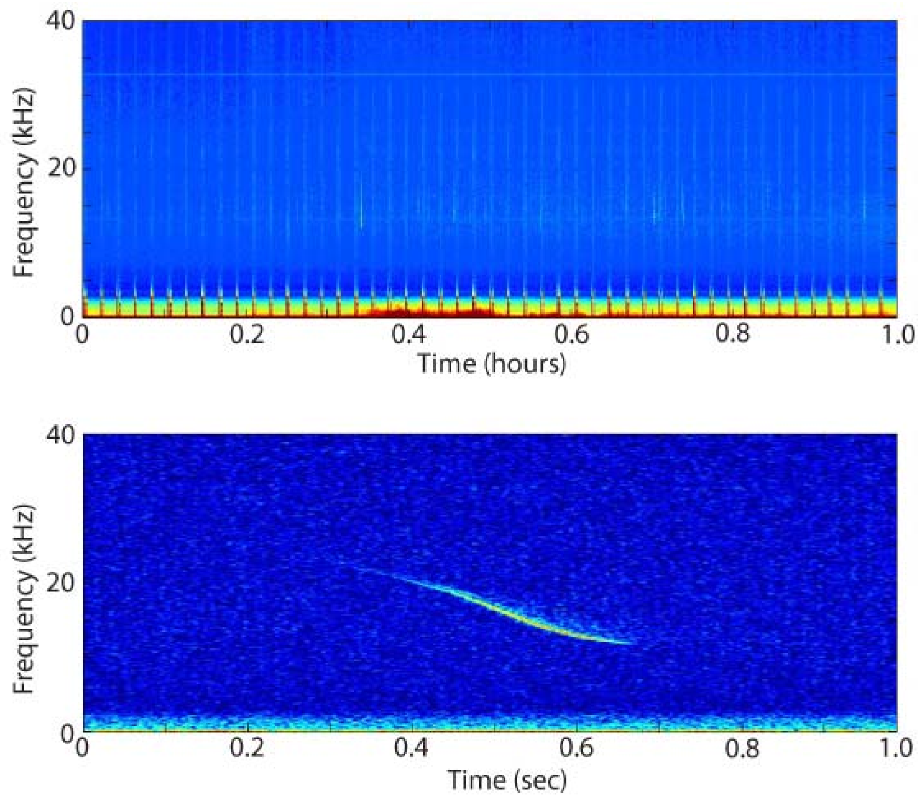

Figure 22. LTSA (above) and spectrogram (below) of killer whale ultrasonic whistle.

Sperm Whale

Sperm whale clicks generally contain energy from 2-20kHz, with the majority of energy between 10-15 kHz (Møhl et al. 2003). Regular clicks, observed during foraging dives, demonstrate a uniform inter-click interval from 0.25-2 seconds (Goold and Jones 1995, Madsen et al. 2002, Møhl et al. 2003). Short bursts of closely spaced clicks called buzzes are observed during foraging dives and are believed to indicate a predation attempt (Watwood et al. 2006). Sperm whales emit regular clicks and buzzes during dives typically lasting about 45 minutes, followed by a quiet period of about 9 minutes while the whales are at the surface (Watwood et al. 2006). Multiple foraging dives and rest periods are often observed over a long period of time in the LTSA (Figure 23). Although ship noise can be confused with sperm whales in the LTSA, in the finer resolution of a spectrogram, the erratic impulses from mechanical noise and prop cavitation can be easily distinguished from the continuous, regular sperm whale clicks.

Sperm whales also produce other clicks, which can be classified as slow clicks and codas. Slow clicks are used only by males and are more intense than regular clicks with long inter-click intervals (Madsen et al. 2002). Codas are stereotyped sequences of clicks which are less intense and contain lower peak frequencies than regular clicks (Watkins and Schevill, 1977, Madsen et al. 2002).

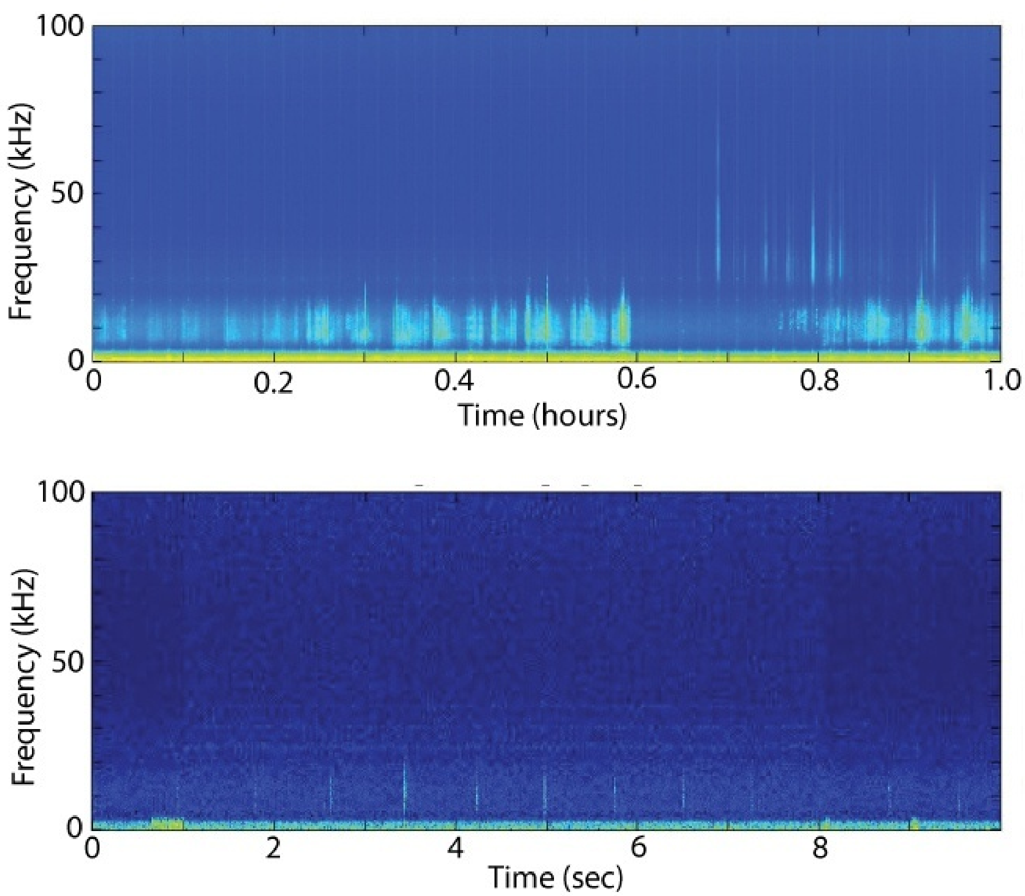

Figure 23. Echolocation clicks of sperm whale in LTSA (above) and spectrogram (below).

Cuvier's Beaked Whale

Cuvier's beaked whale is the most common beaked whale in the Southern California Bight. Cuvier's echolocation clicks are well differentiated from other species' acoustic signals. These clicks are polycyclic, with a characteristic FM upsweep, peak frequency around 40 kHz (Figure 24) and uniform inter-pulse interval of about 0.4s (Johnson et al. 2004, Zimmer et al. 2005).

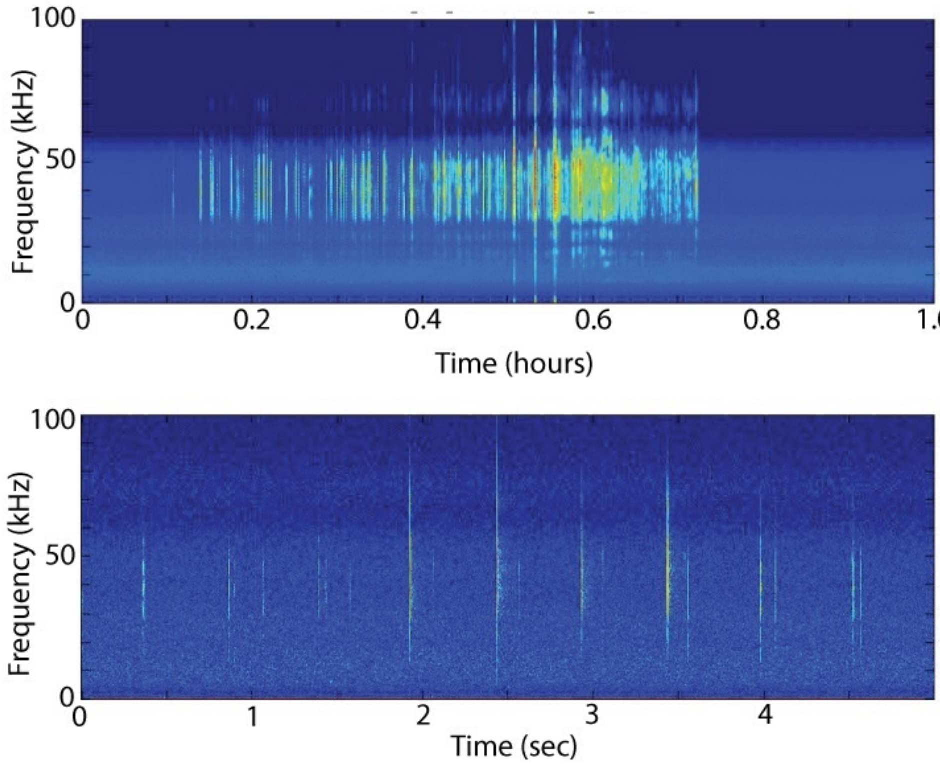

Figure 24. Cuvier's beaked whale clicks in LTSA (above) and spectrogram (below).

Baird's Beaked Whale

Baird's beaked whale is the second most common beaked whale in the Southern California Bight. Baird's echolocation clicks are easily distinguished from other species' acoustic signals and demonstrate the typical beaked whale polycyclic, FM upsweep (Dawson et al 1998). These clicks are identifiable due to the lower frequency than other beaked whale clicks. Spectral peaks are notable around 15, 30 and 50 kHz (Figure 25). Unlike other beaked whales in the area, Baird's beaked whales incorporate whistles and burst pulses into their acoustic repertoire (Dawson et al 1998, Baumann-Pickering et al., in prep).

43 kHz Beaked Whale

The 43 kHz beaked whale echolocation clicks have yet to be assigned to an individual species. These clicks are easily distinguished from other species' acoustic signals and demonstrate the typical beaked whale polycyclic click structure and FM upsweep with a peak frequency around 43 kHz (Figure 26) and uniform inter-pulse interval around 0.2s (Baumann-Pickering et al., in prep).

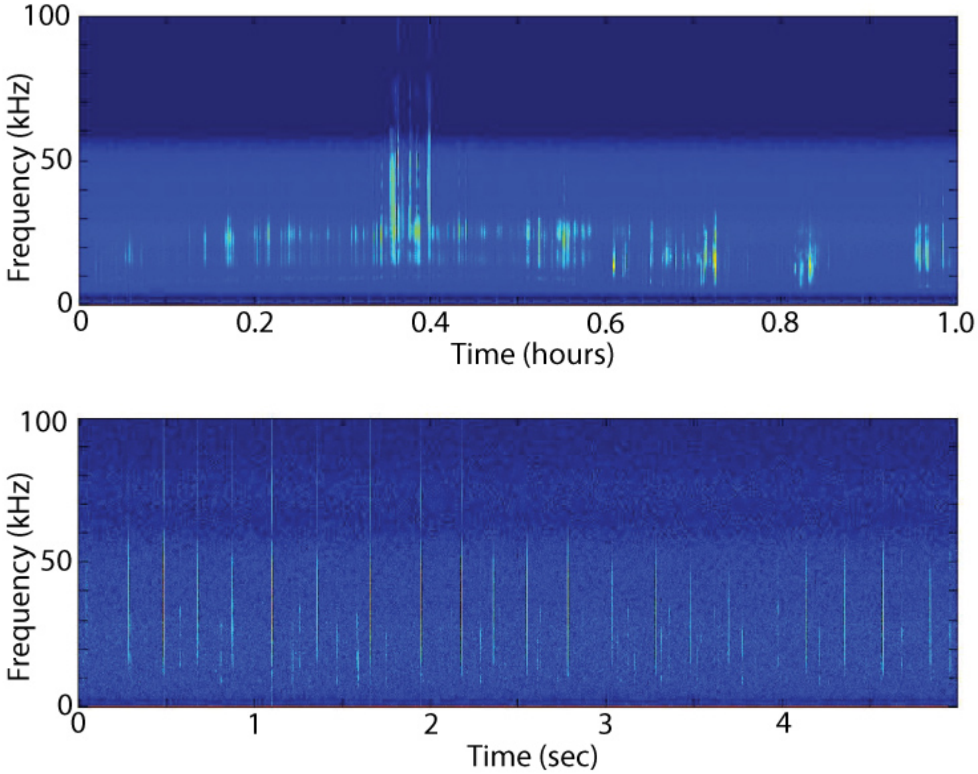

Figure 25. Baird's beaked whale clicks in LTSA (above) and spectrogram (below).

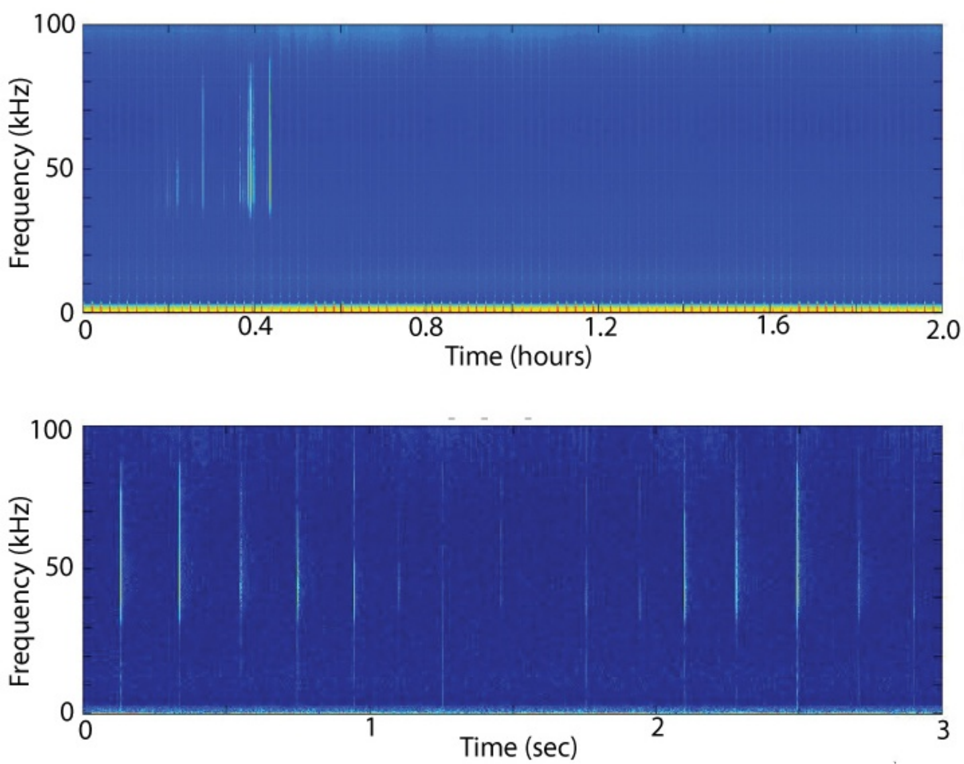

Figure 26. The 43 kHz beaked whale clicks in LTSA (above) and spectrogram (below).

50 kHz Beaked Whale

The 50 kHz beaked whale echolocation clicks have yet to be assigned to an individual species. These clicks are distinct from other species' acoustic signals and demonstrate the typical beaked whale polycyclic click structure and FM upsweep with a peak frequency around 50 kHz (Figure 27) and uniform inter-pulse interval around 0.5s (Baumann-Pickering et al., in prep).

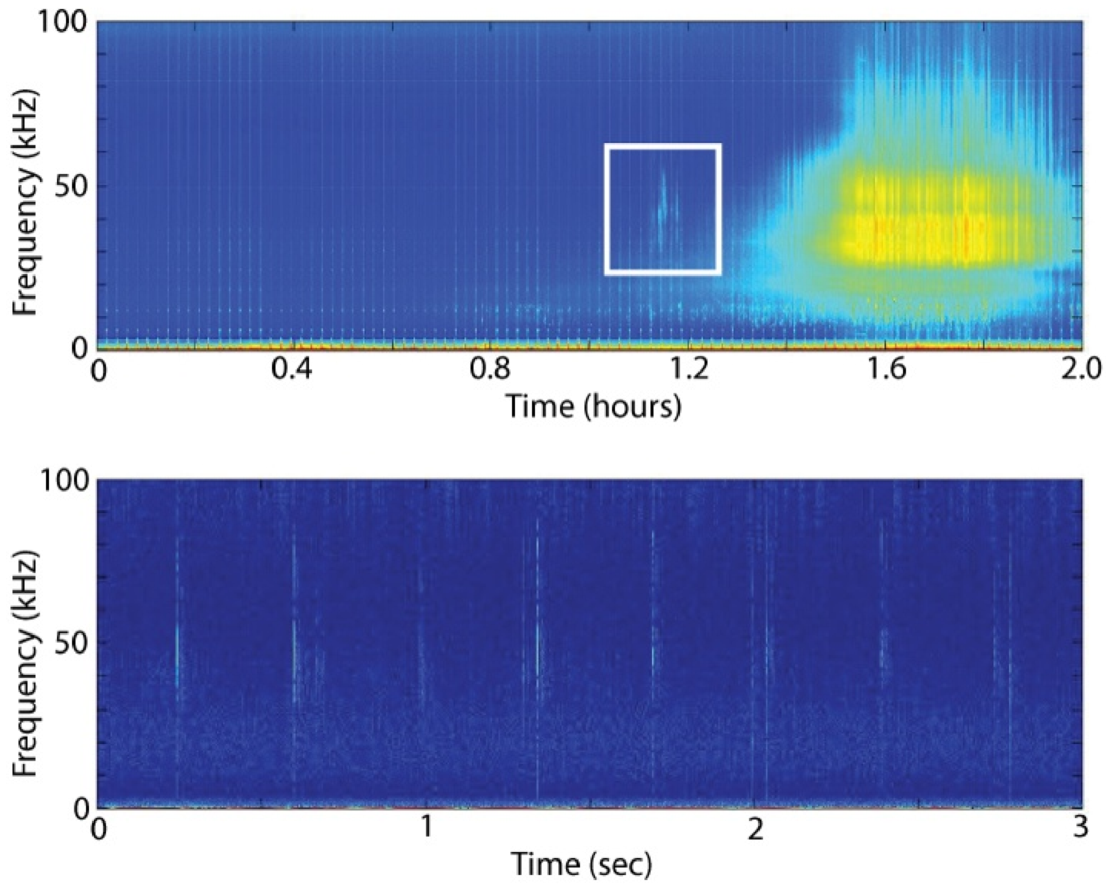

Figure 27. The 50 kHz beaked whale clicks in LTSA (above) and spectrogram (below).

Stejneger's Beaked Whale

Stejneger's beaked whale is primarily known from the north Pacific, but their echolocation clicks are also found in the SOCAL region (Figure 28). Their clicks are easily distinguished from other species' acoustic signals and demonstrate the typical beaked whale polycyclic click structure and FM upsweep with a peak frequency above 50 kHz and uniform inter-pulse interval around 0.1s (Baumann-Pickering et al., in prep).

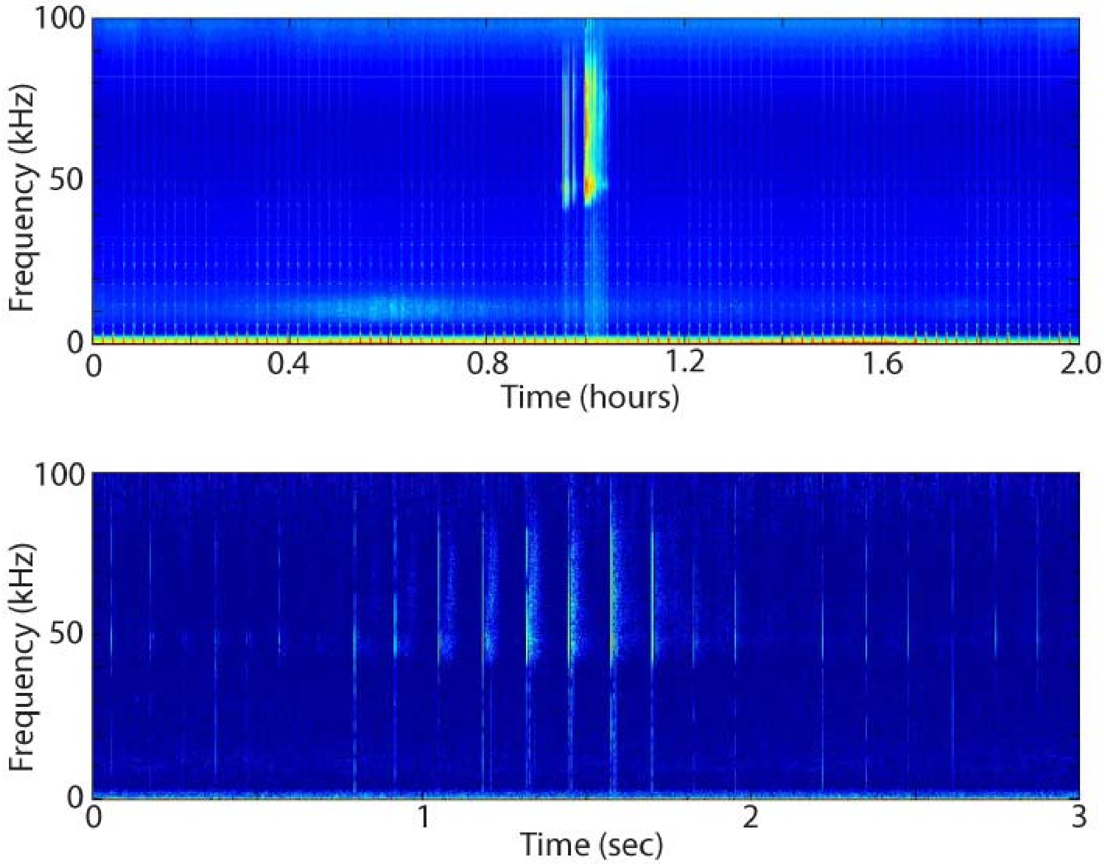

Figure 28. Stejneger's beaked whale clicks in LTSA (above) and spectrogram (below).

Anthropogenic Sounds

Broadband Ship Noise

Broadband ship noise occurs when a ship passes relatively close to the HARP. Ship noise can occur for many hours at a time, but broadband ship noise typically lasts from 10 minutes up to 3 hours. Ship noise has a characteristic interference pattern in the LTSA. Combination of direct paths and surface reflected paths produces constructive and destructive interference (bright and dark bands) in the spectrogram that vary by frequency and distance between the ship and the HARP (red arrows in Figure 29). This noise can extend to well above 10 kHz, though typically falls off above a few kHz.

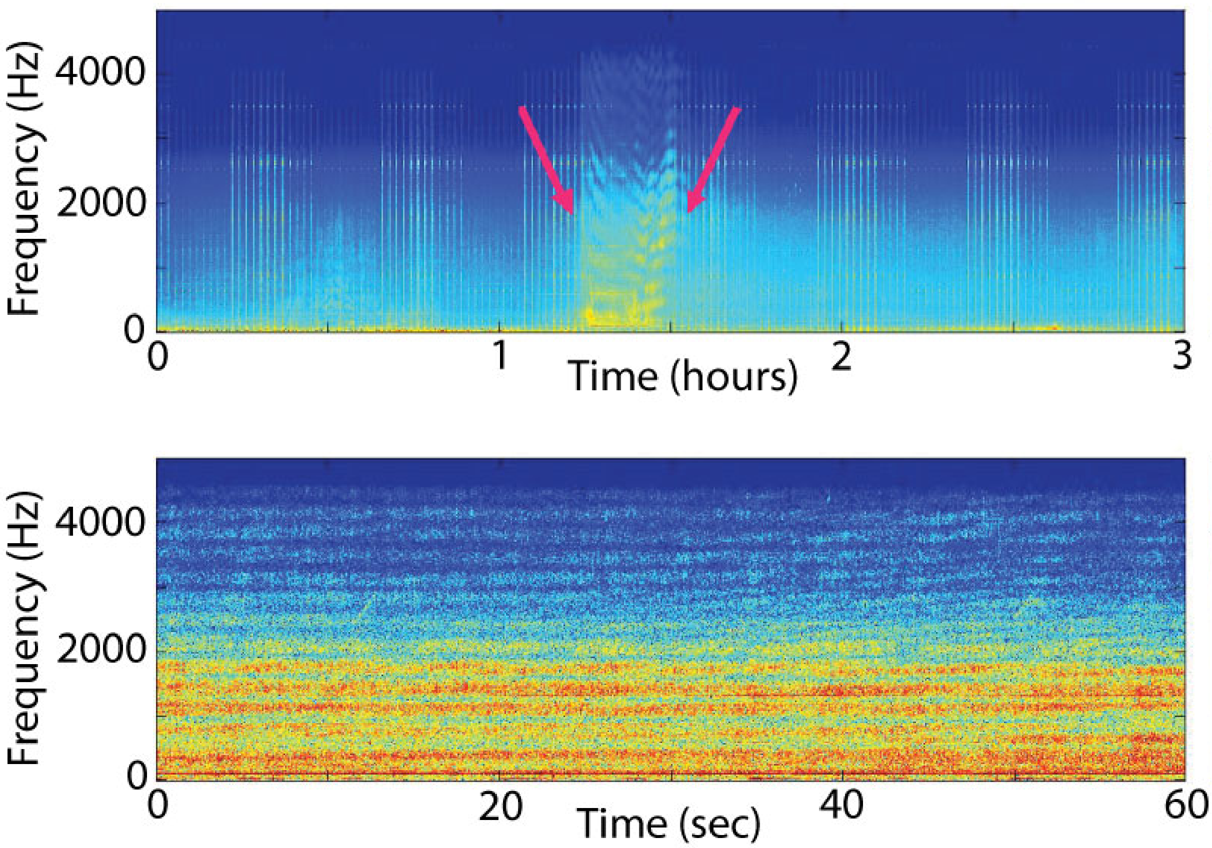

Figure 29. Broadband ship noise in the LTSA (above) and spectrogram (below).

Mid-Frequency Active Sonar

There are many types of active sonar used in the Southern California Offshore Range (SCORE). These span from about 1 kHz to over 50 kHz and include short duration pings, frequency modulated (FM) sweeps and short and long duration continuous wave (CW) tones. One common type of sonar used in SCORE is mid-frequency active (MFA) sonar for anti-submarine warfare (ASW) exercises. Sounds from MFA sonar vary in frequency and duration and can be used in a combination of FM sweeps and CW tones; however, many of these are between 2.0 and 5.0 kHz and are more generically known as '3.5 kHz' sonar. In this section, we describe the process for identifying sessions or events of MFA sonar in recordings from HARPs and how pings from these sessions were analyzed, including counts and distributions of sonar levels.

The first step in analyzing MFA sonar is conducted by an analyst scanning HARP data for periods of sonar activity. Start and end times of MFA sonar events from LTSAs are noted and saved to a file to provide target periods for automatic detections. Full bandwidth (10Hz – 100kHz) data were used to calculate the spectra for the LTSAs with 100 Hz frequency bin width and 5 s time bin width. These spectra are arranged sequentially to provide a long-term spectrogram so that hours of data can be easily displayed on a computer monitor for analysis. Individual MFA sonar pings typically span 1 – 3 s, but are intense enough to show up as 'pulses' in LTSA plots (Figure 30). LTSA display parameters used by the analyst were 1 or 2 hour window length, 2 – 5 kHz window height.

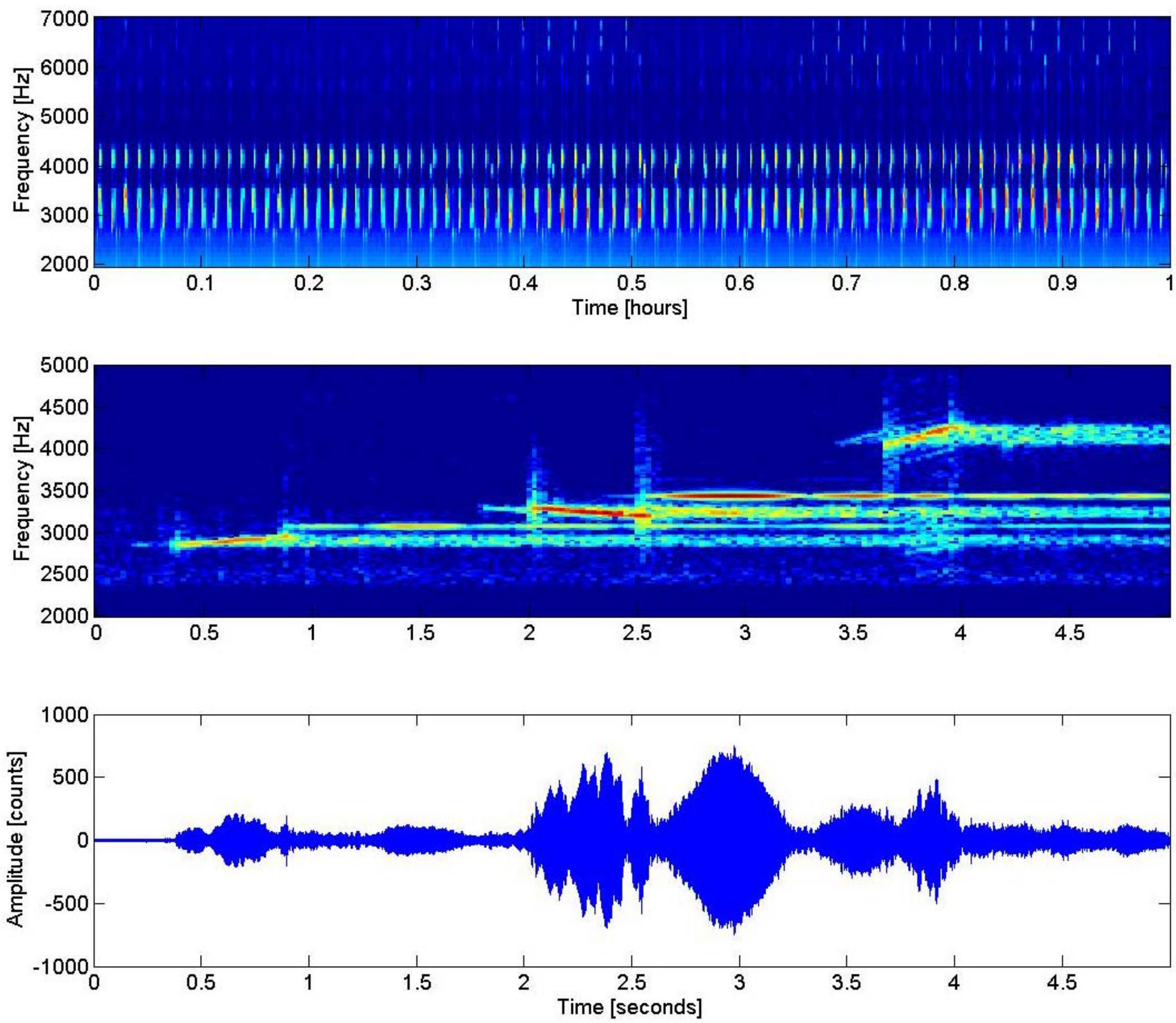

Figure 30. Mid-frequency active (MFA) sonar event (top), Long-Term Spectral Average of one-hour of data (middle) Spectrogram, and (bottom) time series of 5-seconds with multiple sonar pings.

A custom developed software routine was used to detect sonar pings and calculate peak-to-peak (PP) received sound pressure levels. For this detector, a sonar ping is defined as the presence of sonar within the 5 s and may contain multiple individual pings (Figure 30). The detector calculates the average spectrum level across the frequency band from 2.4 to 4.5 kHz for each 5 s time bin. This provides a long-term time series of the average received levels in that frequency band. Minimum values were noted for each 15 time bins, and used as a measure of background noise level over the sonar event period. Spectral bins that contained system noise (disk writing) were eliminated to prevent contaminating the results. Each of the remaining average spectral bins was compared to the background minimum levels. If levels were more than 3 dB above the background, then a detection time was noted. These detection times were then used to index to the original time series to calculate PP levels. Received PP levels were calculated by differencing the maximum and minimum amplitude of the time series in the 5 s window. The raw time series amplitudes are in units of analog-to-digital converter (ADC) counts. These units were corrected to μPa by using the HARP calibrated transfer function for this frequency band. The HARP response is not flat over the 2.4 – 4.5 kHz band, so a middle value at 3.3 kHz was used. The transfer function value used was 81 dB re μPa2/counts2. For sonar pings less than this middle frequency, the levels are overestimated up to about 5 dB and for higher frequency sonar the levels are underestimated up to about 4 dB.

High Frequency Active Sonar

High frequency active sonars were detected by analysts in the LTSA, and are seen as upsweeps with a frequency range from 20 to 30 kHz and an average 4 to 5 s inter-pulse interval (Figure 31).

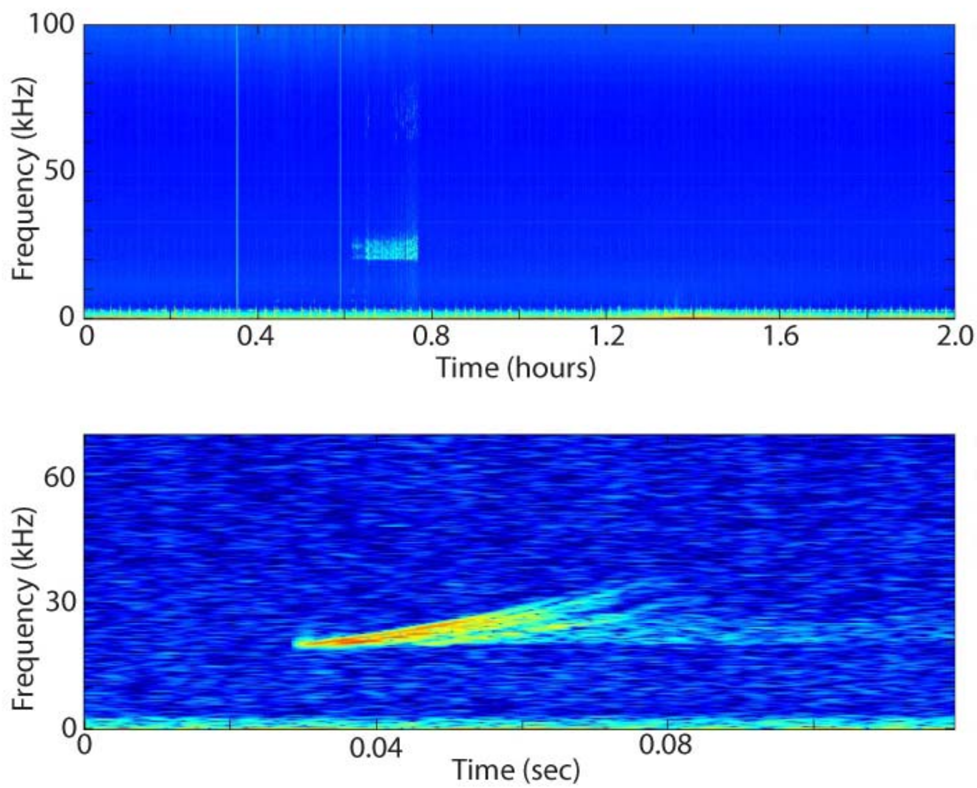

Figure 31. HFA sonar in the LTSA (top), with a single upsweep in the spectrogram (bottom).

Explosions

Explosive sounds logged in the HARP data include military explosions, shots from sub-seafloor exploration, and seal bombs used by the fishing industry. An explosion appears as a vertical spike in the LTSA that when expanded in the spectrogram has a sharp onset with a reverberant decay (Figure 32). These sounds have peak bandwidth as low as10 Hz and often extend up to 2000 Hz or higher, lasting for a few seconds including the reverberation.

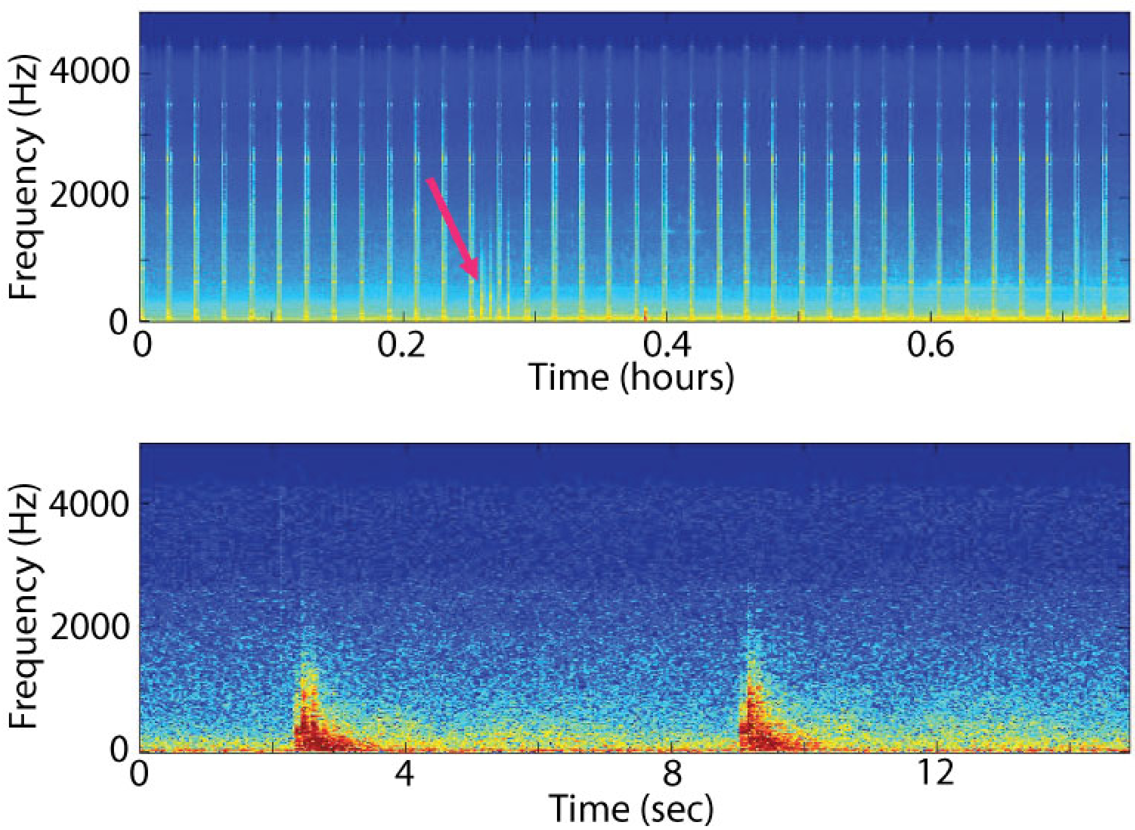

Figure 32. Three explosions are seen in the LTSA (arrow in above) and two of these are expanded in the spectrogram (below).

Results

This report summarizes the results of acoustic data collected from April 2010 - April 2011 at two sites in the SOCAL range area. We discuss ambient noise as well as the seasonal occurrence and relative abundance of marine mammal species and anthropogenic sounds.

Ambient Noise

Underwater ambient noise at sites M and N has spectral shapes with higher levels at low frequencies (Figure 33), primarily owing to the presence of ship noise with secondary contributions from local wind and waves (Hildebrand 2009).

Ambient noise levels at site M are typically 5 dB higher than at site N, consistent with site M's greater exposure to commercial shipping traffic associated with the Ports of Los Angeles and Long Beach. Noise levels at both sites are 5-10 dB less in the fall relative to the spring, probably related to diminished noise from wind and waves. A prominent peak in noise is observed at 20-30 Hz and also at 47 Hz related to the presence of blue and fin whales calls.

Mysticetes

Six baleen whale species were recorded between April 2010 and April 2011 at sites M and N: blue whales, fin whales, Bryde's whales, gray whales, humpback whales, and minke whales. Generally, site N appears to be frequented by calling baleen whales more often than site M, as blue, fin, humpback, and Bryde's whale calls were all detected during more hours at site N. However, gray whale calls were detected only at site M. More details of each species' presence at these sites are given below.

Blue Whales

Blue whales were detected at both sites between April 2010 and January 2011, but consistently more hours with calls were detected at site N (Figure 34). Blue whale calls also were detected between February and April 2011, but during this period they were much less common. Peak in calling at both sites occurred between August and December 2010, which is the period with peak detection of blue whale A and B calls (Figure 35; Figure 36). Similarity in call occurrence between A and B calls is not surprising as they are often produced in a song sequence. Peaks in D call detections, in contract to A and B calls, occurred in July and October 2010 (Figure 37). During peak occurrence, almost twice as many D calls were detected weekly at site N as at site M. This seasonal difference in the occurrence of A and B versus D calls is consistent with previous passive acoustic studies of blue whales in the Southern California Bight (Oleson et al. 2007b) and likely reflects the transition in blue whale behavior from feeding during the summer, to courting or other mating behavior in the fall (Oleson et al. 2007a).

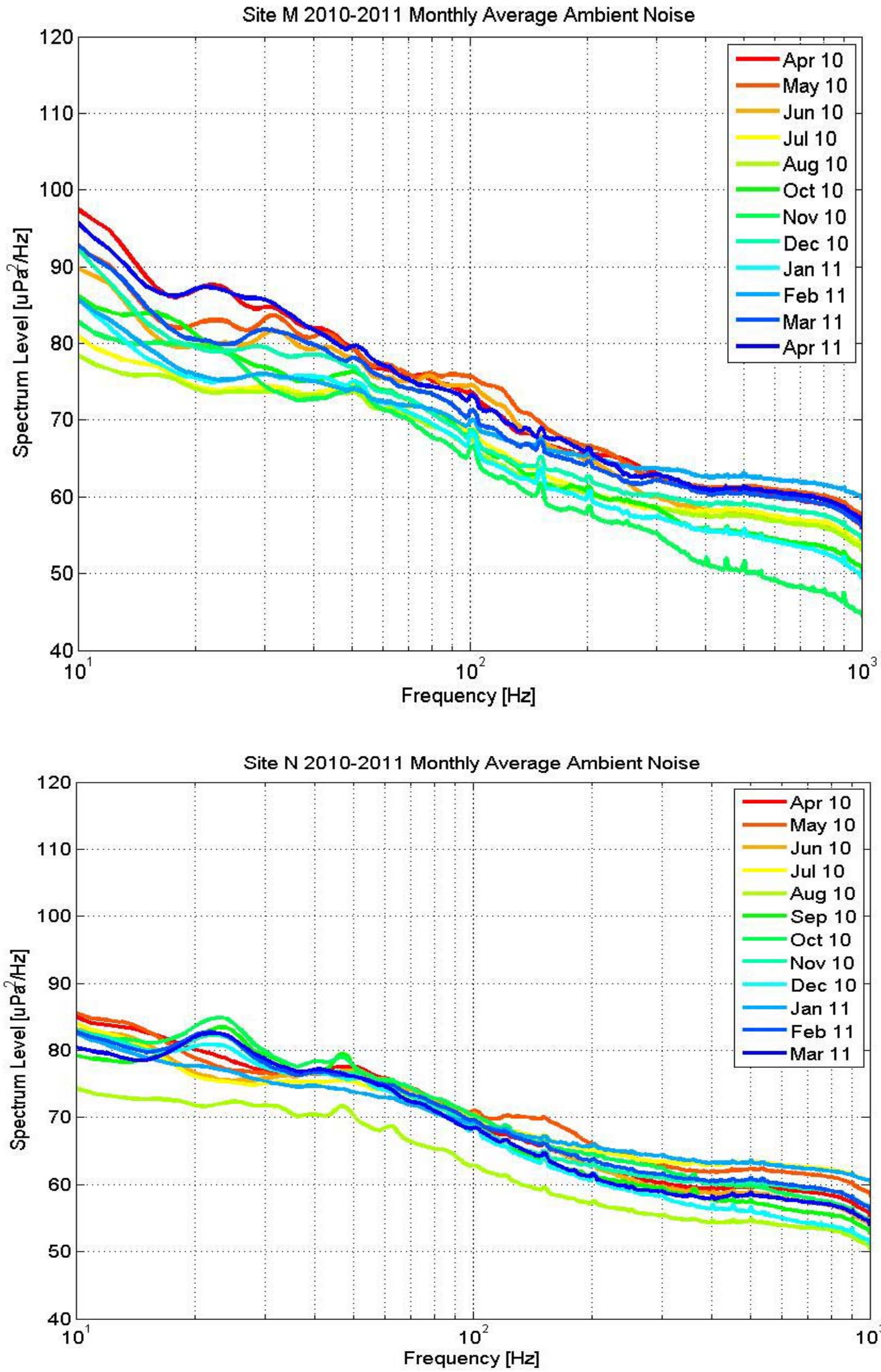

Figure 33. Monthly averages of ambient noise at site M (left) and site N (right) for the period April 2010 – April 2011. Legend gives color-coding by date.

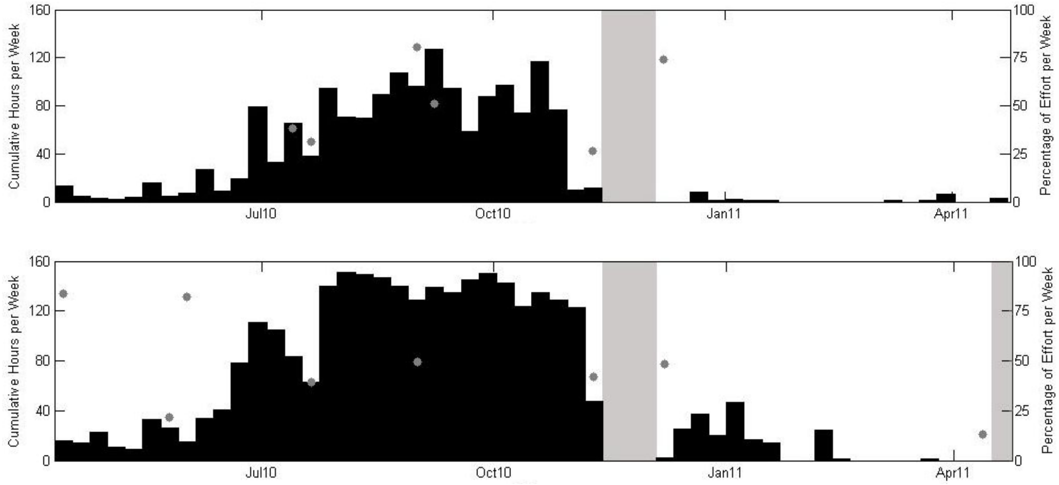

Figure 34. Weekly presence of all blue whale calls (black bars) at sites M (top) and N (bottom) between April 2010 and April 2011. Grey dots represent percent of effort per week in weeks with less than 100% recording effort and grey shading marks periods with no recording effort. Where grey dots or shading are absent, full recording effort occurred for the entire week.

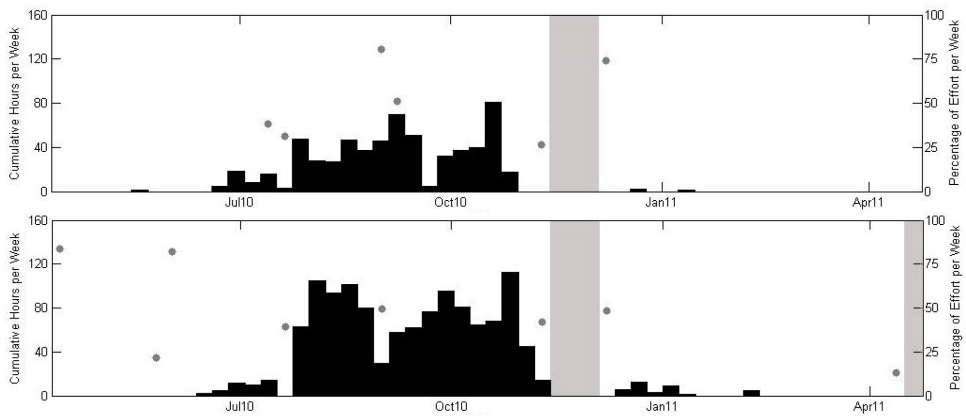

Figure 35. Weekly blue whale A call presence (black bars) at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

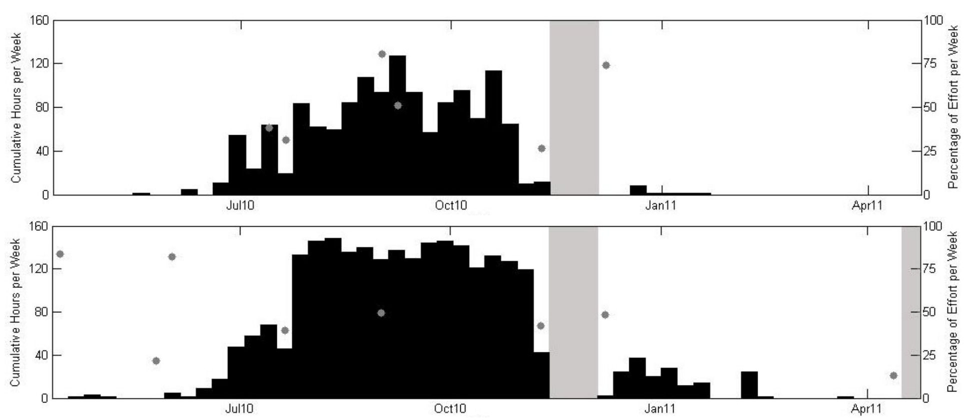

Figure 36. Weekly blue whale B call presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

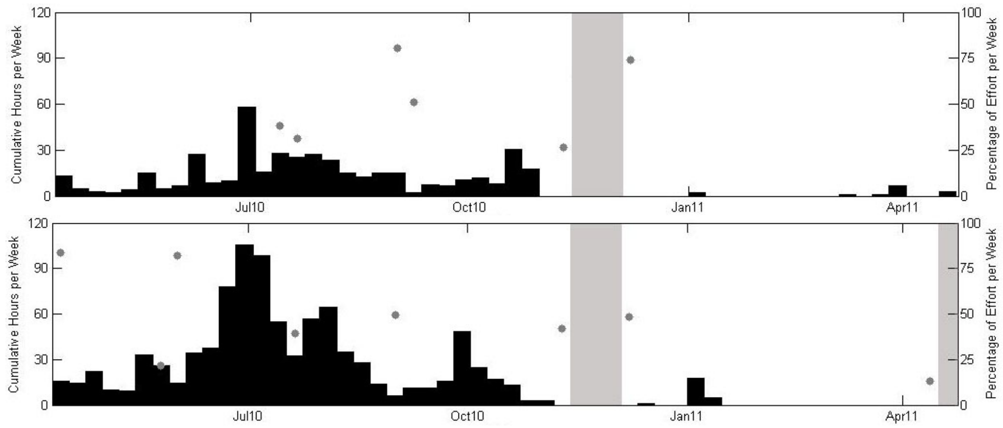

Figure 37 Weekly blue whale D call presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Fin Whales

Fin whales were the most common acoustically detected baleen whale at both sites. Their calls were detected at both sites year-round, but generally, their calls were present during more hours per week at site N (Figure 38). Peaks in calling occurred from August to December 2010, during which period there were eight weeks with almost 100% of hours of fin whale calls present. Secondary peak in fin whale calls were detected in April of both years. Farther offshore in the eastern North Pacific, fin whale calls have been detected from October through April (Watkins et al. 2000). Thus the decrease in calling during the winter at sites M and N may be due to the movement of some part of the population farther offshore. Alternatively, the change in the weekly number of hours with calls could be due to the differences in behavioral state of the whales that may result in different frequency of calling.

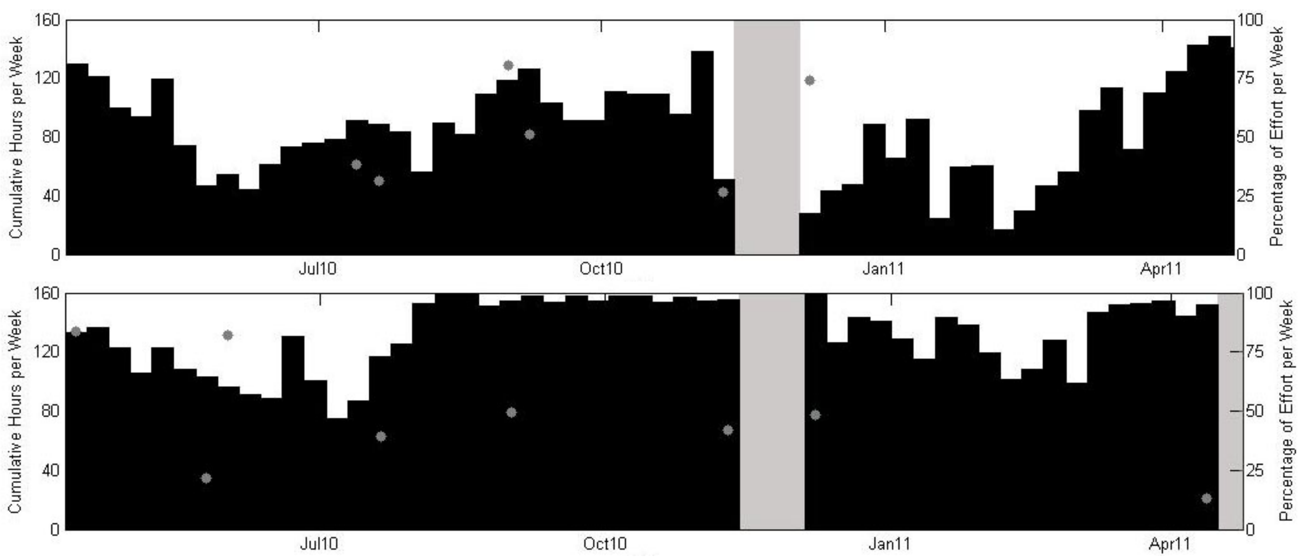

Figure 38. Weekly fin whale 20 Hz call presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described inFigure 34.

"50 Hz" Whales

An additional baleen whale sound, 50 Hz call, was frequently recorded at both sites (Figure 39). Watkins (1981) attributed this call to fin whales although we found them to not be as common as the more typical 20 Hz fin whale pulses. Likewise, seasonality of the 50 Hz call differs from 20 Hz calls; 50 Hz calls were more prominent between April and August 2010 (Figure 39), whereas fin whale 20 Hz pulses were more prominent in the fall (Figure 38). There are three possibilities for the source of this 50 Hz call: (1) the 50 Hz calls are produced by a sub-population of fin whales (distinct from the 20z Hz producing whales), (2) the 50 Hz calls represent a distinct behavioral state for fin whales (e.g. communication between nearby animals as suggested by Watkins 1981), or (3) the 50 Hz calls are produced by a baleen whale species other than fin whales. Thus, we categorized the 50.

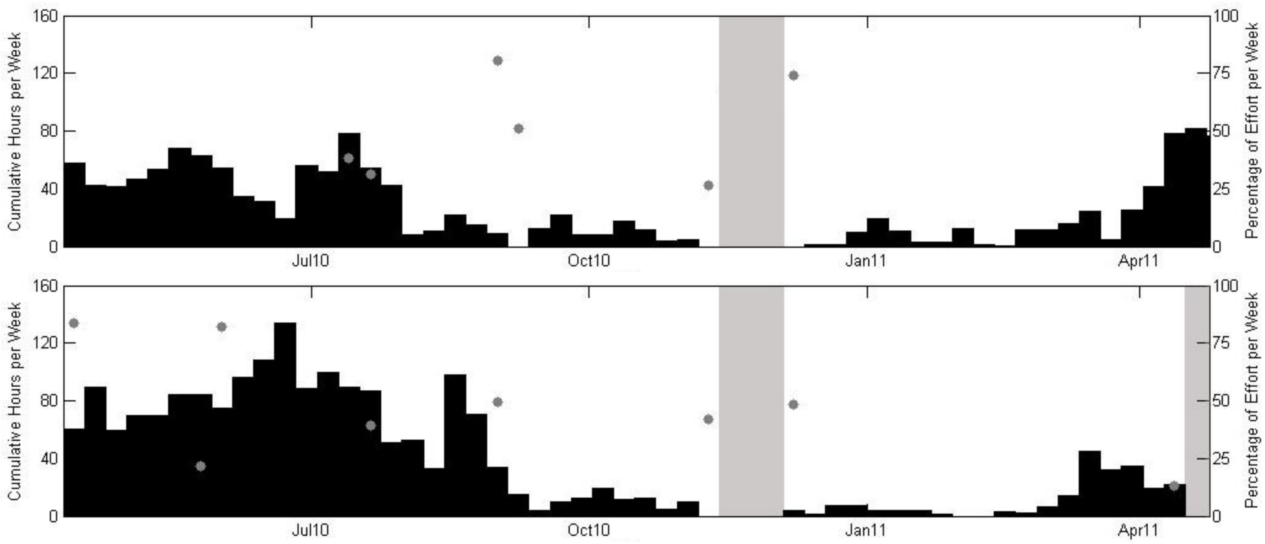

Figure 39. Weekly unknown whale 50 Hz call presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Bryde's Whales

Bryde's whale calls were first detected at sites M and N in August 2010 (Figure 40). The peak number of weekly hours with calls occurred in November 2010 at both sites, though, at site N, there was another peak in weekly hours with Bryde's whale calls in January 2011. The last Bryde's whale calls were detected at both sites in February 2011. This represents a later arrival to site N and a later departure of Bryde's whales from both sites than during the winter 2009/10 (Hildebrand et al., 2010a and 2010b).

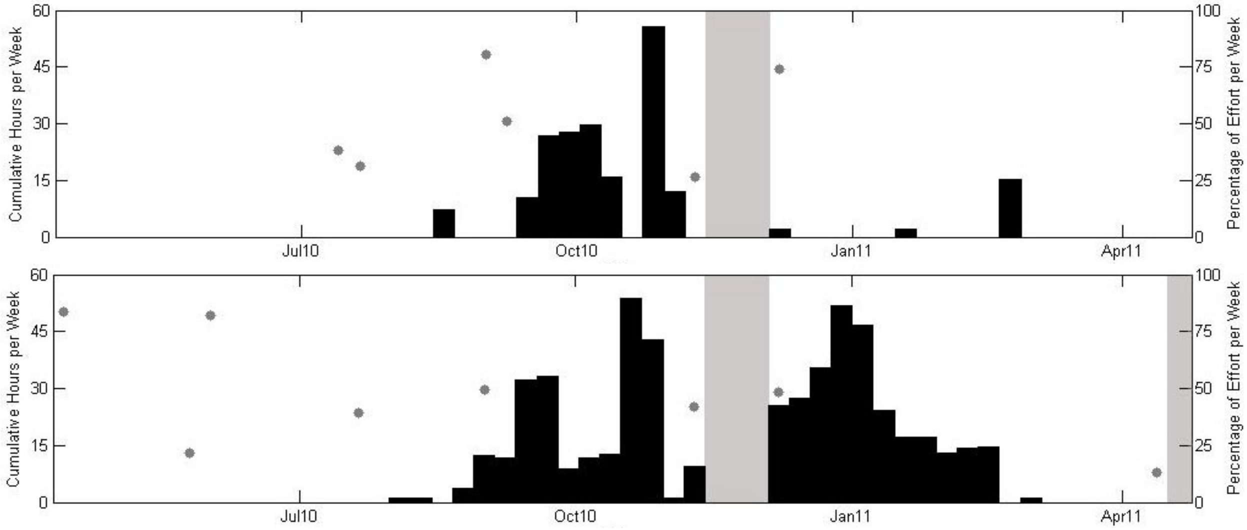

Figure 40 Weekly Bryde's whale call presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Gray Whales

Of the two gray whale call types found in the data (M1 and M3) M3 was the more common, which is consistent with previous studies of gray whale sounds off California (Crane and Lashkari 1996). Gray whales were only detected at one of the sites, M, during the time period reported here (Figure 41). The lack of calls at site N is likely due to the offshore location of this site, while site M is on a path between northern Channel Islands and Catalina or San Clemente islands, which the migrating gray whales likely use (Sumich and Show, 2011). The two peaks in the data probably represent the southbound migration in January/February and northbound migration in March/April.

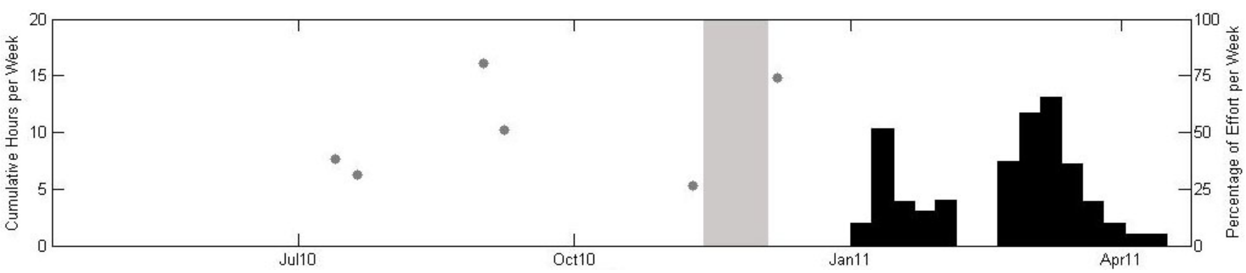

Figure 41 Weekly gray whale call presence at site M between April 2010 and April 2011. Effort markings are as described in Figure 34. No gray whales were detected at site N during this time period.

Humpback Whales

Both song and non-song call types were grouped for this analysis of humpback whale presence. Humpback whales were detected at both sites year-round, although like other baleen whales, they were more common at site N (Figure 42). While the number of weekly hours with humpback whale calls was more persistent year-round at site M, both sites had peaks in calling in November 2010, January-February 2011, and April 2011. Site N had generally higher number of hours with calls in the winter and through April 2011. Humpback whales are known to feed off California in spring, summer, and fall (Calambokidis et al. 1996) which is the time with a low number of hours with calls at site N. It is likely that vocalizing humpbacks are engaged in a behavior other than feeding and thus may not be as readily available for visual surveys during the winter period.

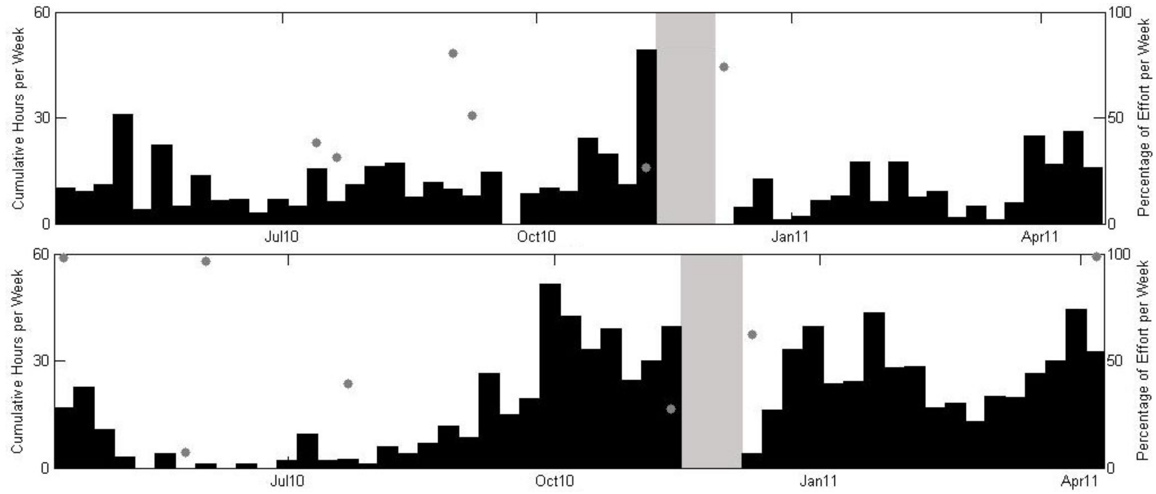

Figure 42. Weekly presence of all humpback whale calls (black bars) at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

<u>Minke Whales</u>

Minke whale boings were the rarest baleen whale sounds recorded between April 2010 and April 2011 (Figure 43). No minke whales were recorded after November 2011 at either site. Off Hawaii, where Minke boing sounds are more common, they occur between February and June, peaking in early April, although data are lacking on other months (Oswald et al. 2008). Based on two full years of monitoring at sites M and N (Hildebrand et al. 2010a and 2010b), presence of boings is rare at these sites, but appears to be most likely to occur in the spring and fall months.

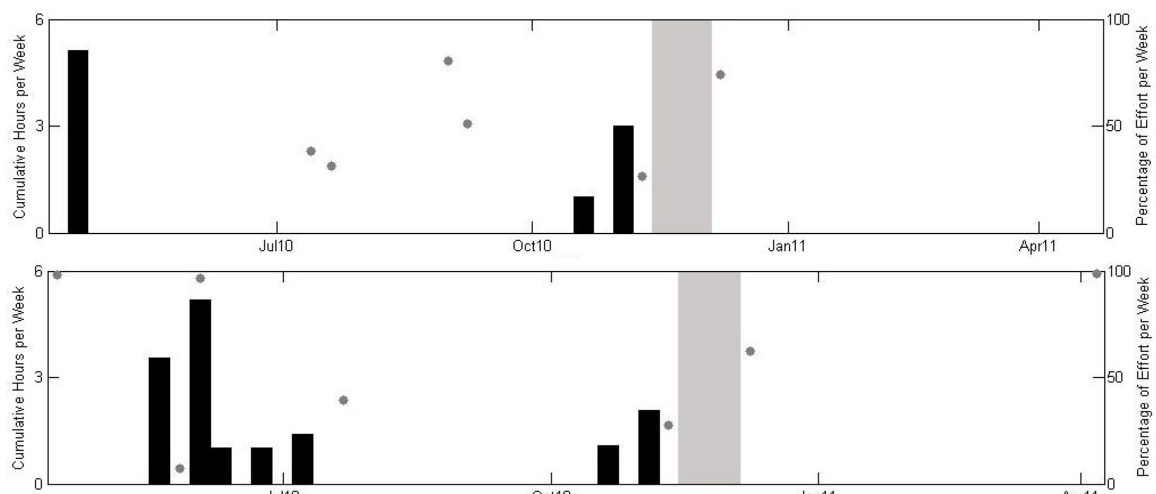

Figure 43. Weekly minke whale boing call presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Pinnipeds

Sea Lion

Pinniped barks, presumably made by California sea lions, were recorded a lot more frequently at site M than N, and most of them were recorded during July and August 2010 at both sites (Figure 44). Low level of barking persisted at site M until February. Site N may be too far from shore and islands to be appropriate for barking pinnipeds.

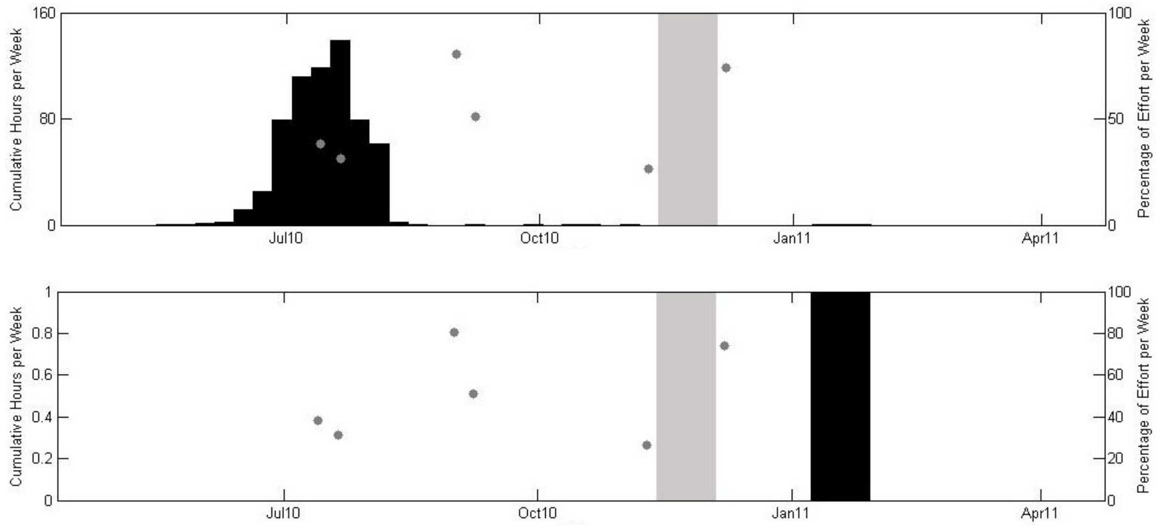

Figure 44 Weekly pinniped bark presence at site M between April 2010 and April 2011. Effort markings are as described in Figure 34. No pinnipeds were detected at site N during this time period.

Odontocetes

Unidentified Dolphin

The largest number of odontocete detections for echolocation clicks and whistles were attributed to the category "unidentified dolphin" which is primarily comprised of short- and long-beaked common dolphins as well as bottlenose dolphins. Unidentified dolphins were detected throughout the year with a peak acoustic activity in late summer and fall months. Overall numbers of detections were slightly higher at site N than M. Number of detections declined intermittently with no apparent pattern (Figure 45, Figure 46). There was a very distinct diel acoustic activity, likely due to nighttime foraging, which was more apparent for click and less for whistle detections (see Appendix).

During some echolocation click detections, clicks were broadband but with significant energy below 20 kHz. These detections were categorized as unidentified dolphin with low frequency echolocation clicks. Further investigation is needed to classify these clicks to the species level. Potential species producing these types of clicks are killer whales, false killer whales and short-finned pilot whales (Baumann-Pickering et al., unpublished data). All of these species are not common to the Southern California Bight and accordingly seldom are detections of low echolocation clicks. Due to the low number of detections, seasonality is not clearly apparent but there was a higher rate of detections towards late fall at both sites (Figure 47).

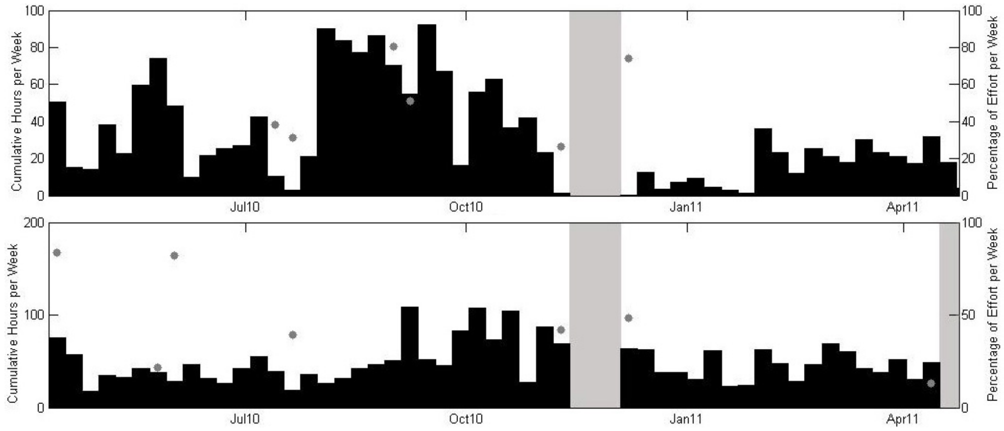

Figure 45. Weekly unidentified dolphin echolocation click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

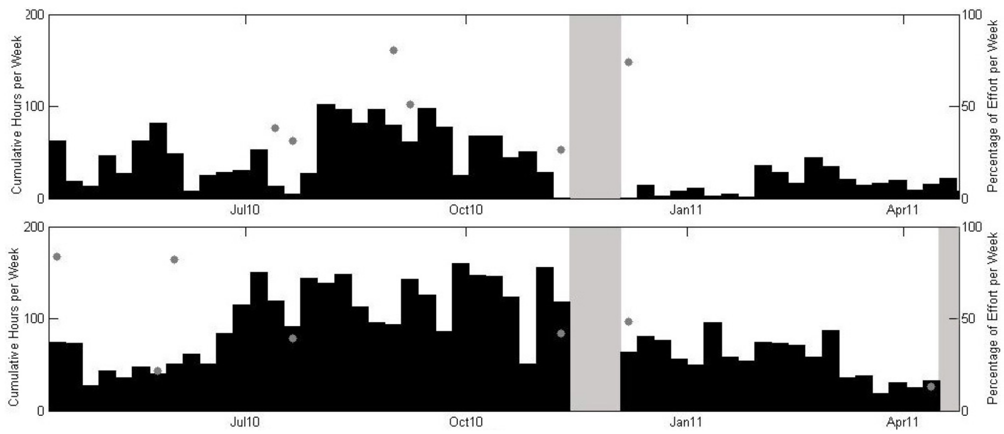

Figure46. Weekly unidentified dolphin whistle presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

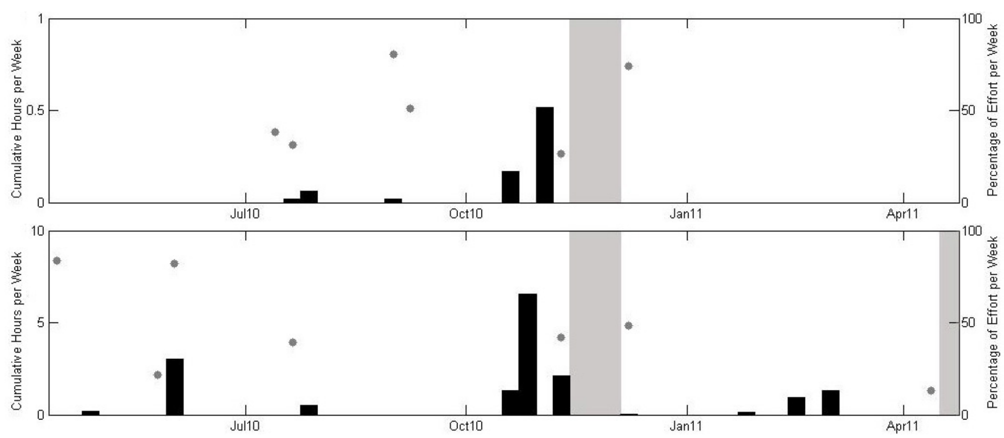

Figure 47. Weekly unidentified dolphin low frequency echolocation click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

Risso's Dolphin

Risso's dolphin echolocation clicks occurred throughout the year with increased detections in winter and early spring months at site M in 2011 and late spring at site N in 2010. They were generally more frequent at site M than N (Figure 48). In the previous year, site M also was preferred over site N by this species while their peak occurrence was then during summer months at both sites (Hildebrand et al. 2010a and 2010b). They showed a diel pattern with higher echolocation click activity at night indicating nighttime foraging (see Appendix). This is consistent with what is reported by Soldevilla et al. (2010a).

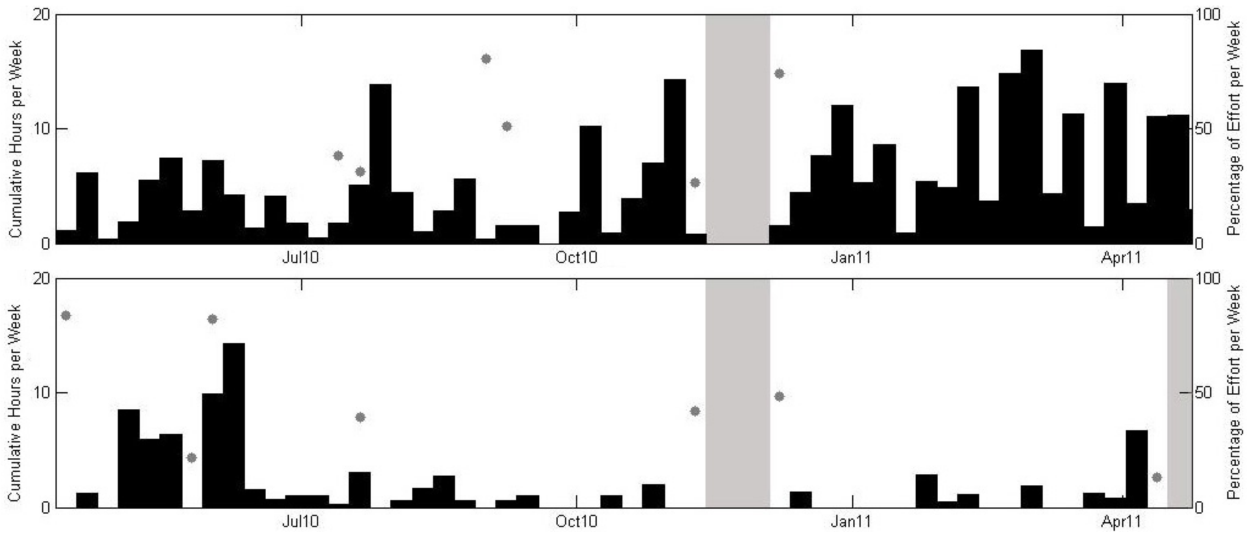

Figure 48. Weekly Risso's dolphin echolocation click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Pacific White-Sided Dolphin

Pacific white-sided dolphin echolocation clicks of type A were present distinctly more often at site N than M. They had a seasonal occurrence with higher detections from November 2010 until March 2011 (Figure 49). There was a diel pattern notable with higher numbers of detections at night indicating nighttime foraging (see Appendix). Echolocation clicks of type B were overall very seldom with highest detections at site M in late spring and early summer (Figure 50). There was a higher rate of detections during daytime (see Appendix). Nighttime foraging of type A Pacific white-sided dolphins and daytime foraging of type B was observed, as described by Soldevilla et al. (2010b). The northern extent of type B, however, was reported at Santa Catalina Island. Since site M is north of Santa Catalina Island, it is currently the northernmost site with acoustic detections of this click type. A fall-winter peak was expected for both click types (Soldevilla et al. 2010b) and type A follows the expected pattern. Type B, however, had a spring occurrence.

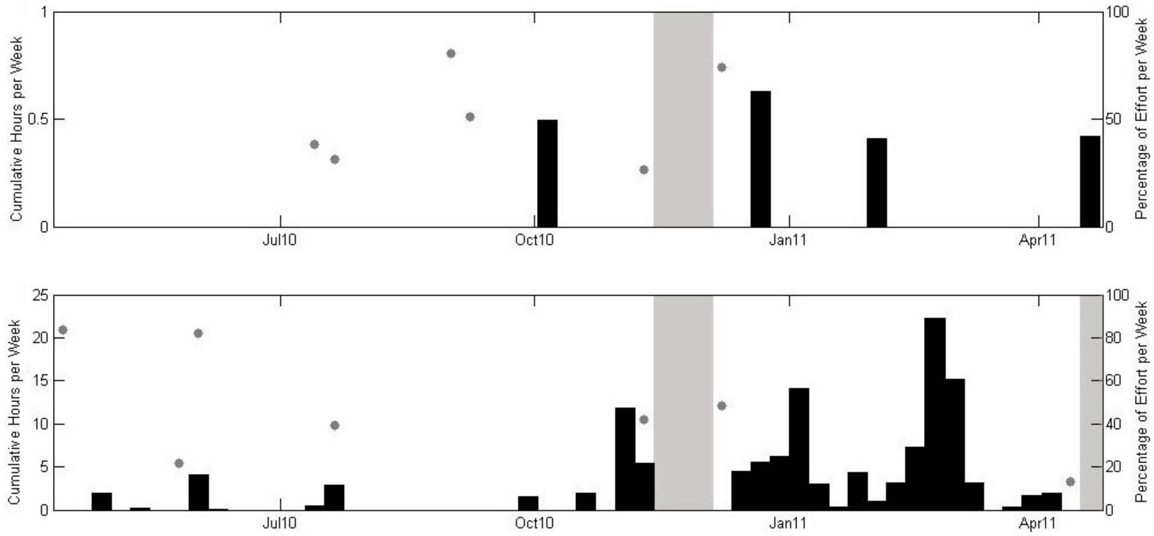

Figure 49. Weekly Pacific white-sided dolphin type A echolocation click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

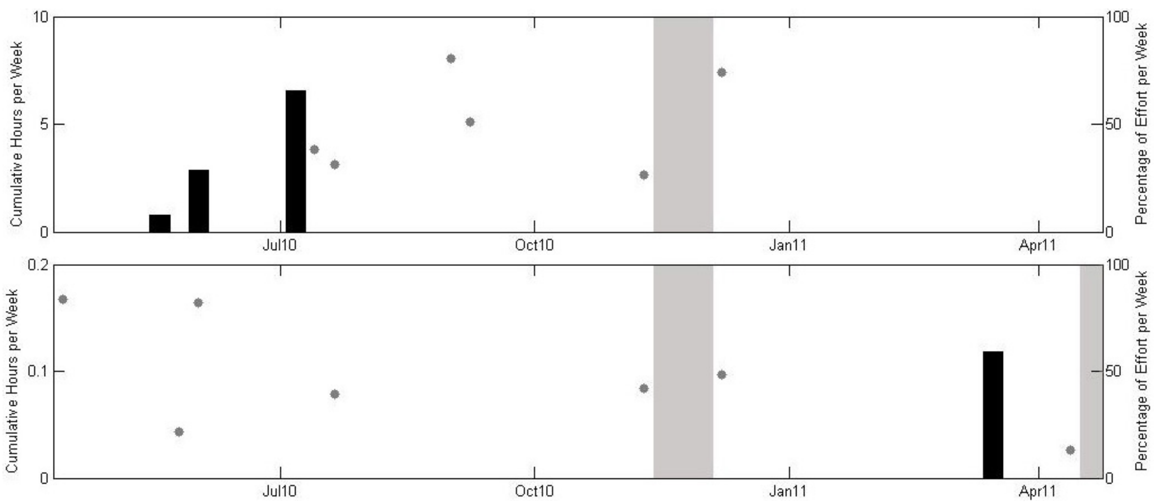

Figure 50. Weekly Pacific white-sided dolphin type B echolocation click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

<u>Killer Whale</u>

Killer whale detections were overall very few and with no apparent pattern or site preference. The large number of detections in April 2011 at site N was likely artificial due to partial recording effort in that week and normalization to a full week of effort (Figure 51).

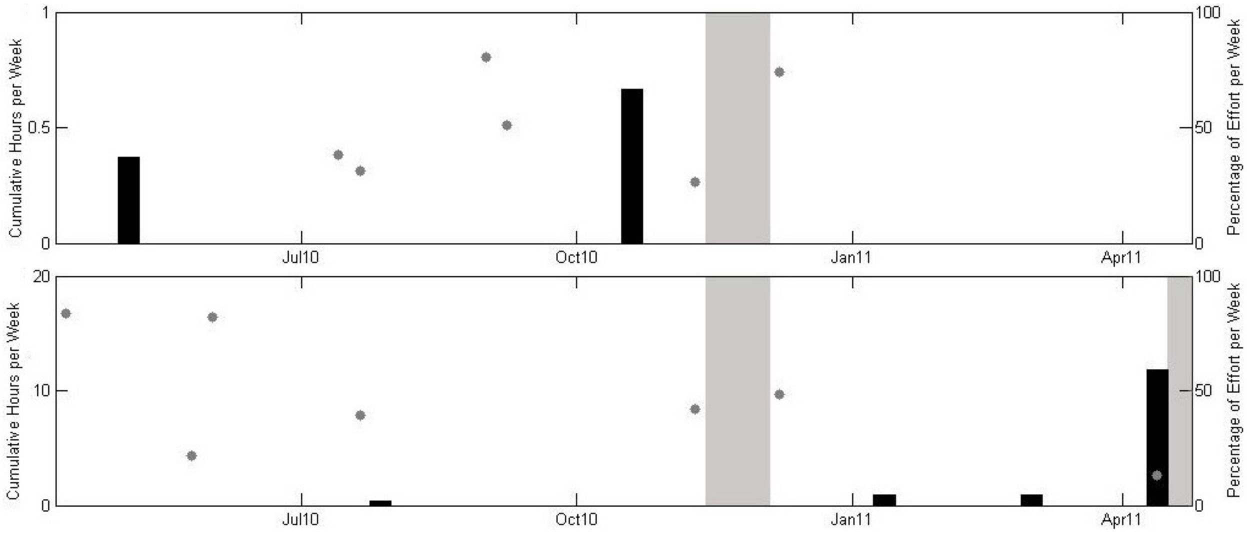

Figure 51. Weekly killer whale presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

Sperm Whale

Sperm whale echolocation clicks were detected throughout the year without apparent seasonal pattern but in general there were more frequent detections at site M (Figure 52). This is in contrast to last year's analysis that showed more hours with sperm whale echolocation clicks at site N (Hildebrand et al. 2010a and 2010b). There may be a preference for daytime acoustic activity (see Appendix).

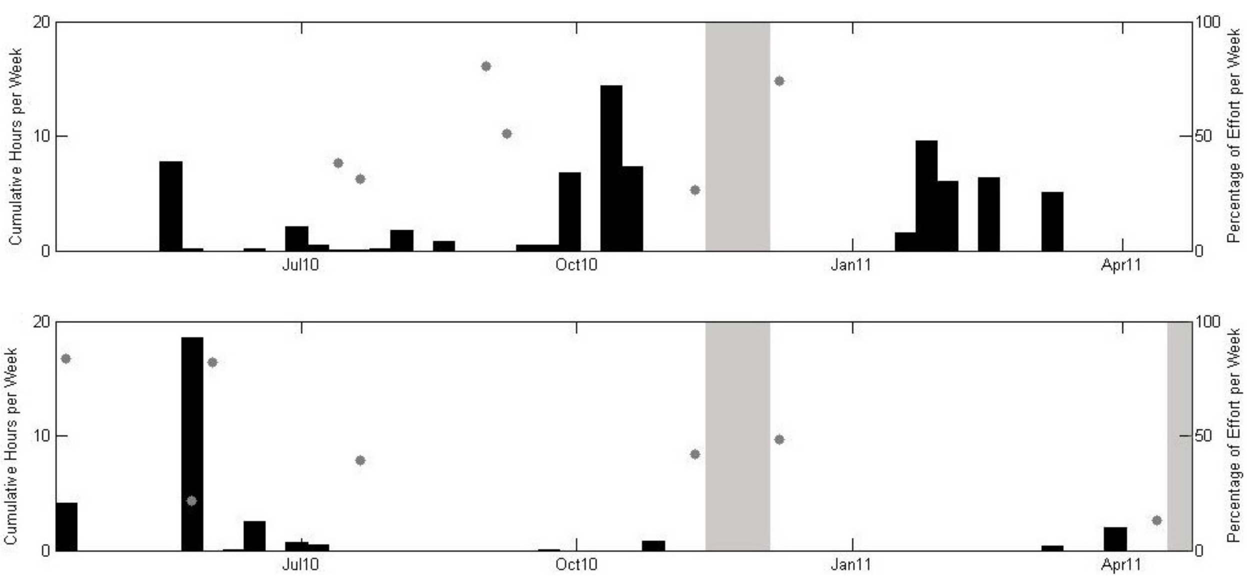

Figure 52. Weekly sperm whale echolocation click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Cuvier's Beaked Whale

Cuvier's beaked whales were detected throughout the year at both sites with a higher number of occurrences at site N (Figure 53). There was no clear seasonal pattern visible but there was a period with lower detections from July to October and in April at site M as well as from September to January at site N. Highest numbers of detections were counted at the end of April in 2010. There was no preferred time of the day for echolocation click detections.

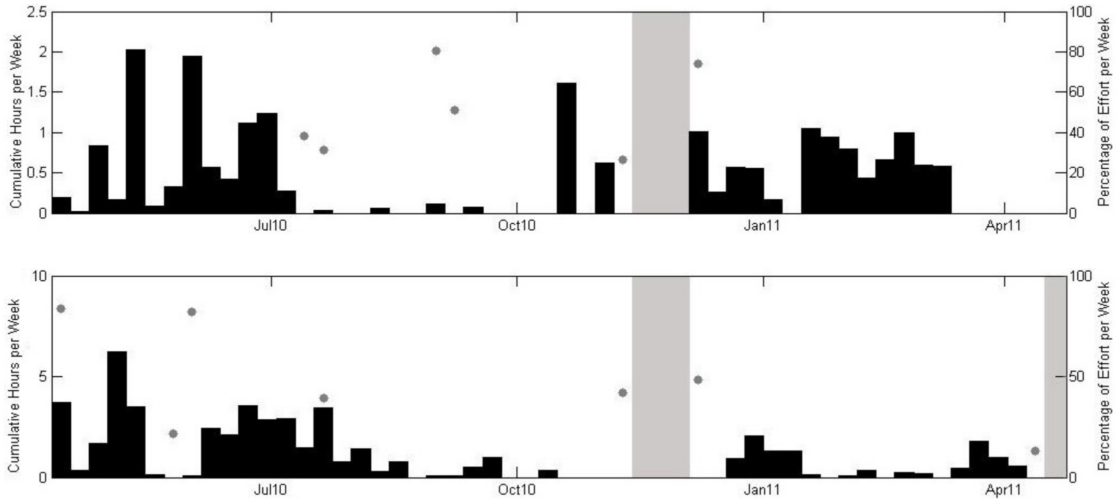

Figure 53. Weekly Cuvier's beaked whale frequency modulated pulse presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

Baird's Beaked Whale

There were only a few detections of Baird's beaked whales; they were found in December 2010 and January 2011 at sites M and in May 2010 at site N (Figure 54).

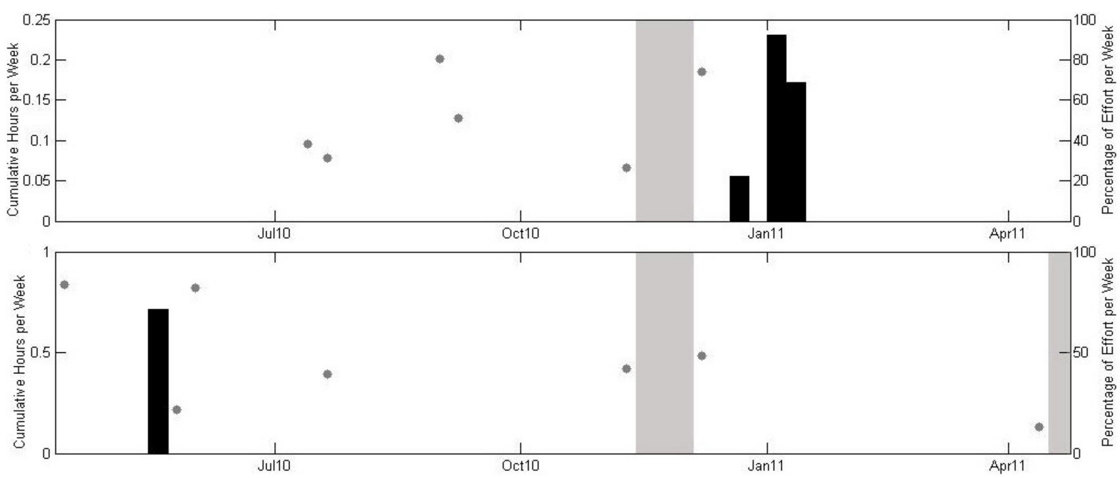

Figure 54. Weekly Baird's beaked whale frequency modulated pulse and click presence at sites M (top) and N (bottom) between April 2010 and April 2011. Note y-axis in different scale. Effort markings are as described in Figure 34.

Unidentified Beaked Whales

Detections of unidentified beaked whale frequency modulated (FM) pulses were very rare and due to the lack of data with no apparent diel or seasonal pattern. A group of possible Stejneger's beaked whales with signals reminiscent to those described from the Aleutian Islands were detected during three consecutive days in the end of July 2010 at site M (Figure 55 top). FM pulses with 50 kHz peak frequency were detected once early February 2011 at site M (Figure 55 middle) and with 43 kHz peak frequency once at site N in late January 2011 (Figure 55 bottom).

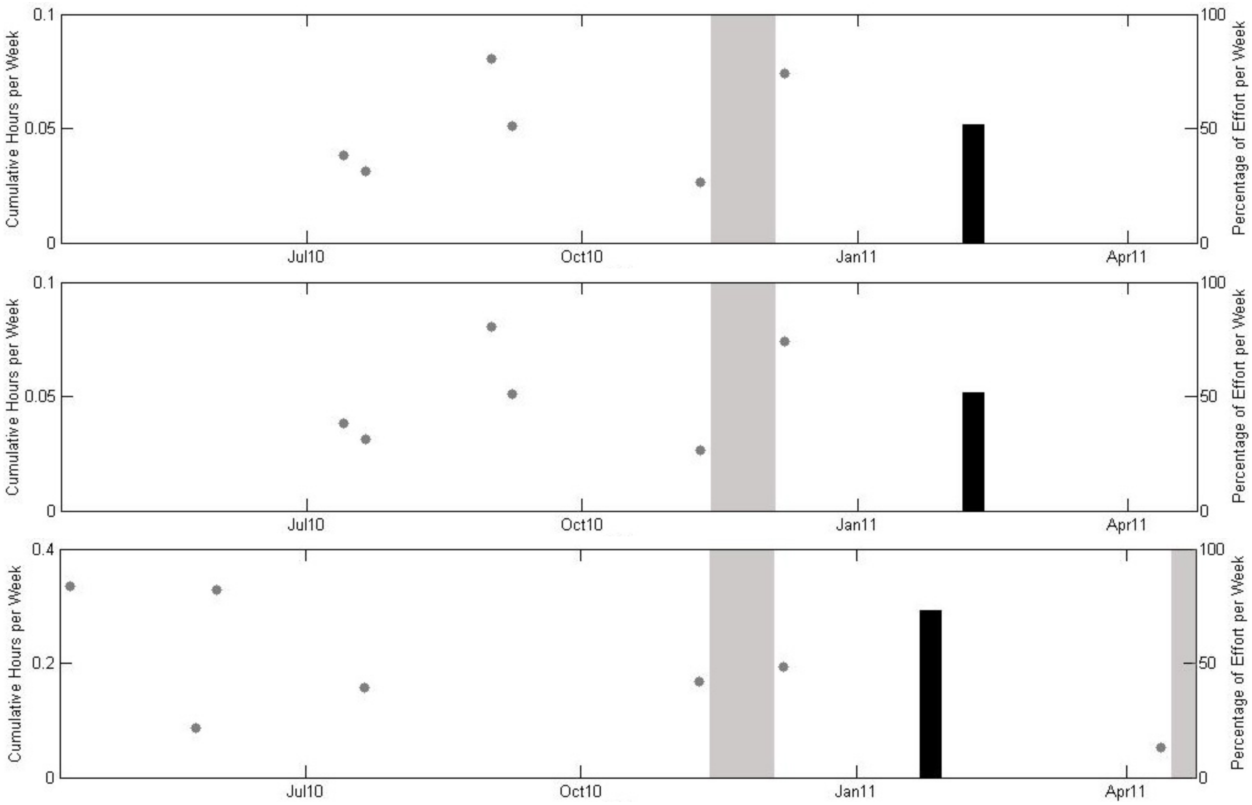

Figure55. Weekly unidentified beaked whale frequency modulated (FM) pulse presence between April 2010 and April 2011. FM pulses reminiscent to likely Stejneger's beaked whale signals identified at the Aleutian Islands were present at site M (top). FM pulses with a peak frequency of 50 kHz were detected at site M (middle) and with a peak frequency of 43 kHz at site N (bottom). Note y-axis in different scale. Effort markings are as described in Figure 34.

Anthropogenic Sounds

Broadband Ship Noise

Ship noise was the most common anthropogenic sound at sites M and N, although it was more common at site M (Figure 56). Site M is on the south side of the northern Channel Islands, on the route for ships embarking at the Ports of Los Angeles and Long Beach. Daily patterns of ship noise with two temporal peaks (see Appendix) shows the preference in times for ship arrival and departure to port.

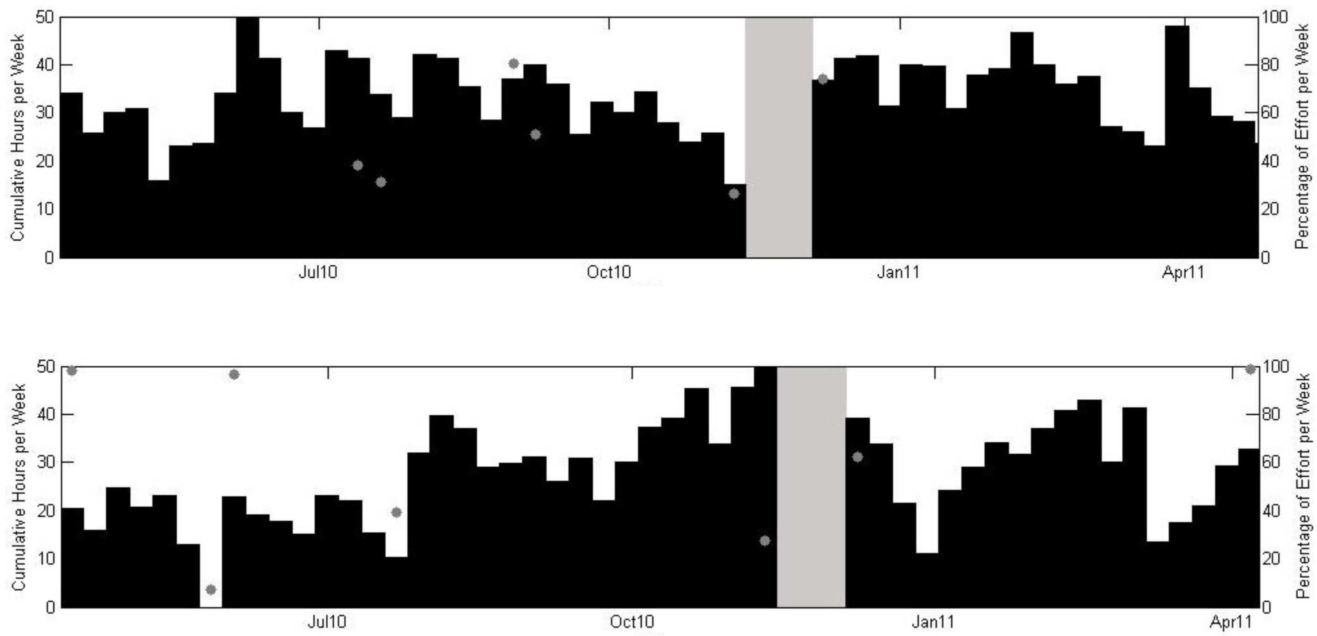

Figure 56. Weekly hours with broadband ship noise at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Mid-Frequency Active Sonar

Both sites M and N had MFA sonar events throughout the period April 2010 – April 2011 (Figure 57). At site N, over 55,000 MFA sonar pings were detected, ranging from 105 to 170 dB pp re 1 μPa; the maximum value is the clipping level of the HARP and the minimum value is a threshold limit based on the analysis methods used. Early December had the largest number of pings per week detected (~12,000) while some weeks did not have any detections. Distribution of ping levels from site N in 1 dB bins shows a peak around 120 dB pp re 1 μPa and is long-tailed to higher levels (Figure 58). Cumulative distribution of ping levels shows that half of the pings detected are above 125 dB pp re 1 μPa (Figure 59). While site M had MFA sonar events recorded, the received levels and the number of pings for these events were often much lower (e.g. < 120 dB pp re 1 μPa and 10's of pings/event) than at site N. These low levels precluded the use of the automated detection and received level routine on many of the low intensity (presumably distant) events from site M; however, one event in early August 2010 with about 800 pings was from a close source as received levels were almost up to the clipping level at 170 dB pp re 1 μPa.

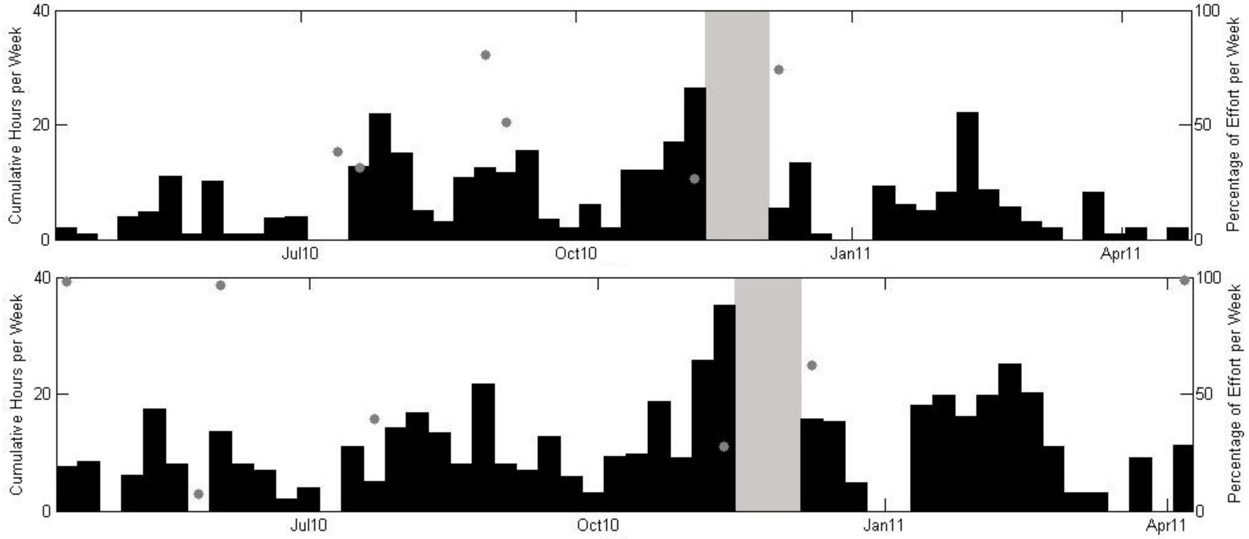

Figure 59. Weekly mid-frequency active (MFA) sonar presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

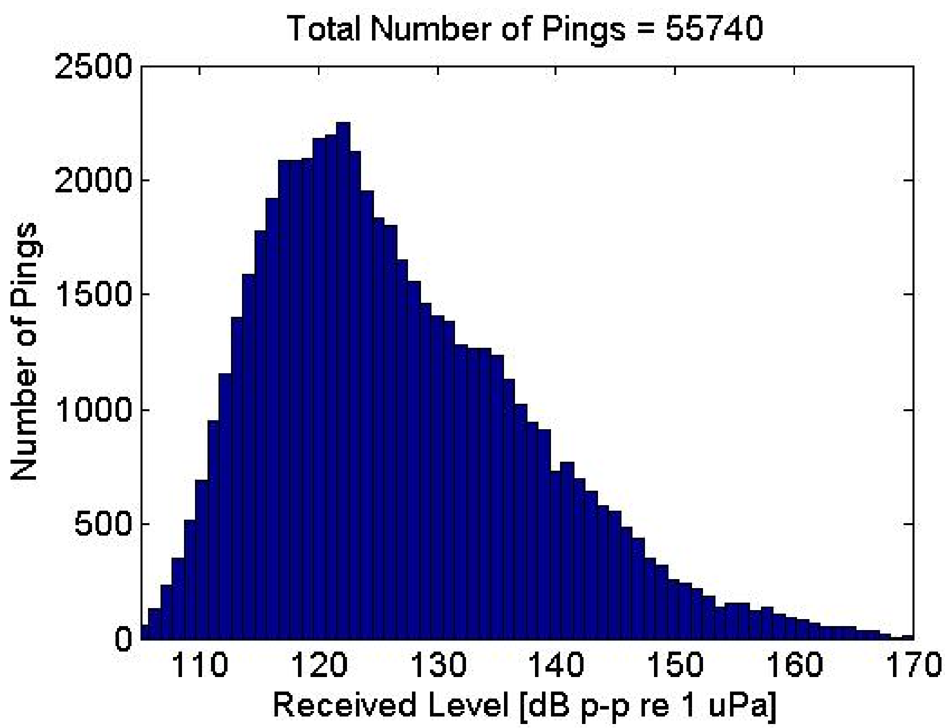

Figure 58 Distribution of number of MFA sonar pings by received levels at site N in 1 dB bins. Peak number of pings is at 120 dB pp re 1 μPa. Minimum level is 105 dB pp re 1 μPa and is related to the detection threshold and maximum level is 170 dB pp re 1 μPa which is the clipping level of the HARP. The period from early September to late November is not included in this analysis pending further data processing.

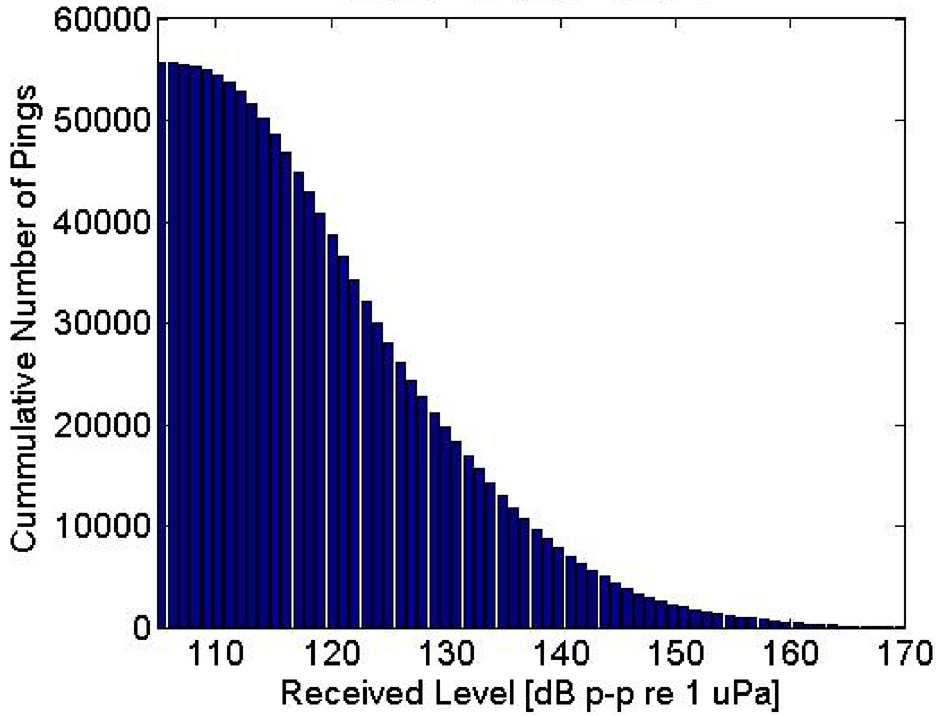

Figure 59 Cumulative distribution of the number of MFA sonar pings detected at site N by received level in 1 dB bins. One-half of the pings are above about 125 dB pp re 1 μPa.

High Frequency Active Sonar

High Frequency Active (HFA) sonar was infrequently detected at both sites M and N (Figure 60). A list of some HFA sonar events and their characteristics is given in Table 4.

Table 4: Frequency and inter-pulse interval features of HFA sonar during five detections with mean and standard deviation.

Date	Inter-pulse Interval	Start Frequency	End Frequency	Frequency Range
2/2/2011 3:37	8.2±2.7	19.7±0.2	28.0±0.9	8.4±1.0
2/5/2011 20:36	4.4±0.5	19.7±0.6	27.6±1.1	7.9±1.5
2/6/2011 0:08	4.2±0.4	19.5±0.5	28.9±0.8	9.5±0.8
2/6/2011 1:19	4.9±1.6	19.5±0.3	29.7±0.8	10.2±0.8
3/7/2011 12:37	4.2±0.4	19.8±0.2	25.2±0.6	5.4±0.6

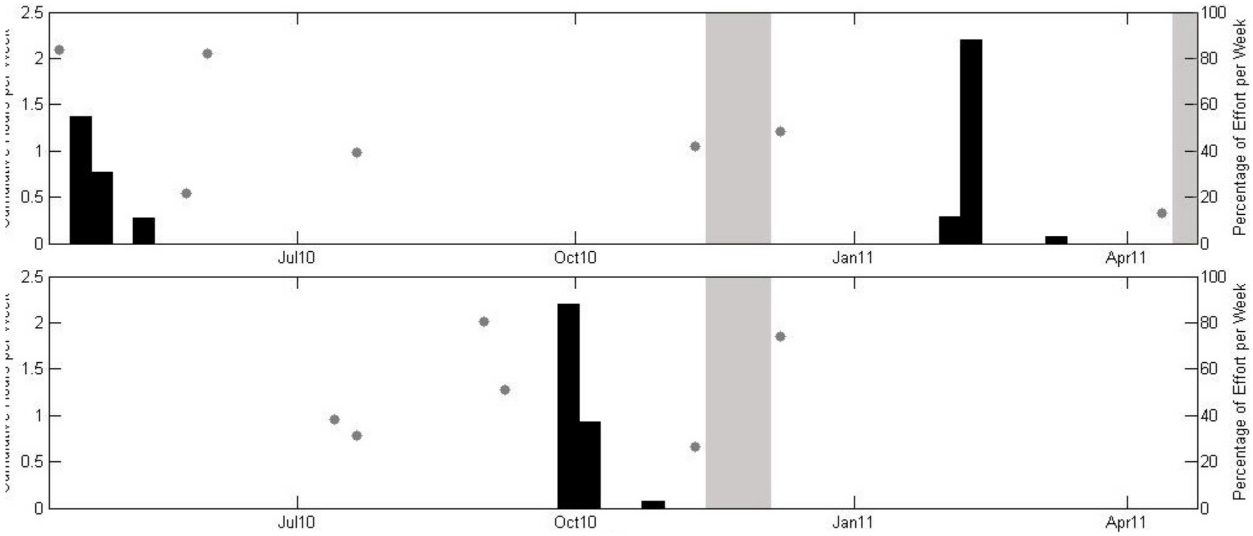

Figure 60. Weekly high frequency active sonar presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Echosounders

Echosounder pings with a variety of primary frequencies (8 – 80 kHz) were found at both sites M and N (Figure 61). More echosounders were present at site M than at site N, perhaps related to the presence of higher numbers of commercial vessels. The occurrence of these pings had no apparent seasonal cycle.

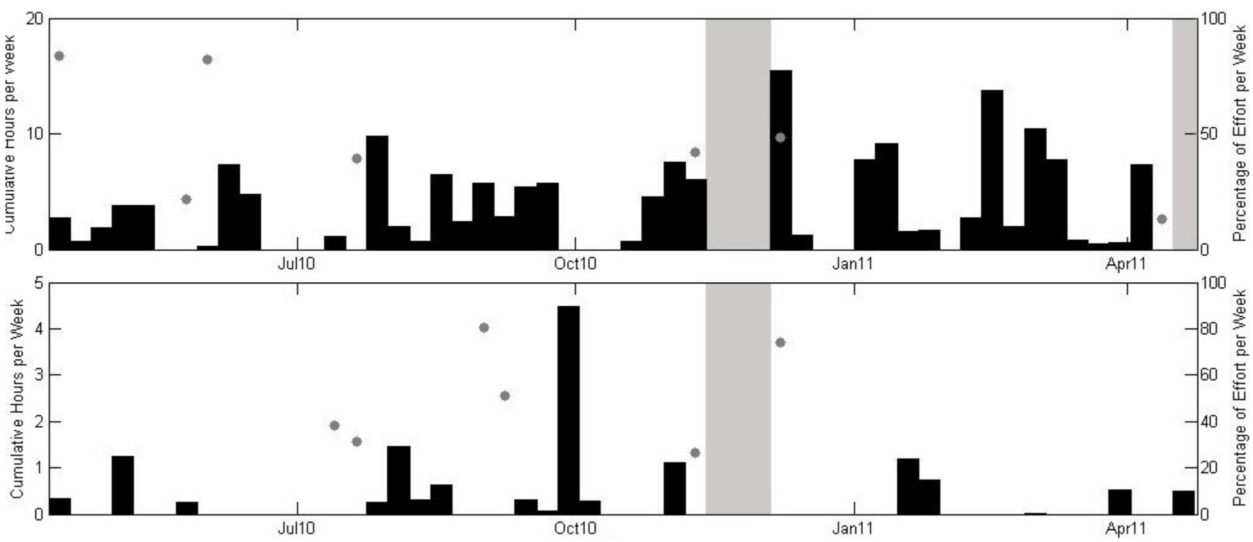

Figure 61. Weekly echosounder ping presence at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

Explosions

Up to 60 and 30 hours with explosions per week were recorded at sites M and N, respectively (Figure 62). Peak in explosions at site M was recorded in December 2010, while at site N it was in October 2010. There is somewhat of a tendency for explosions to occur at night (Appendix).

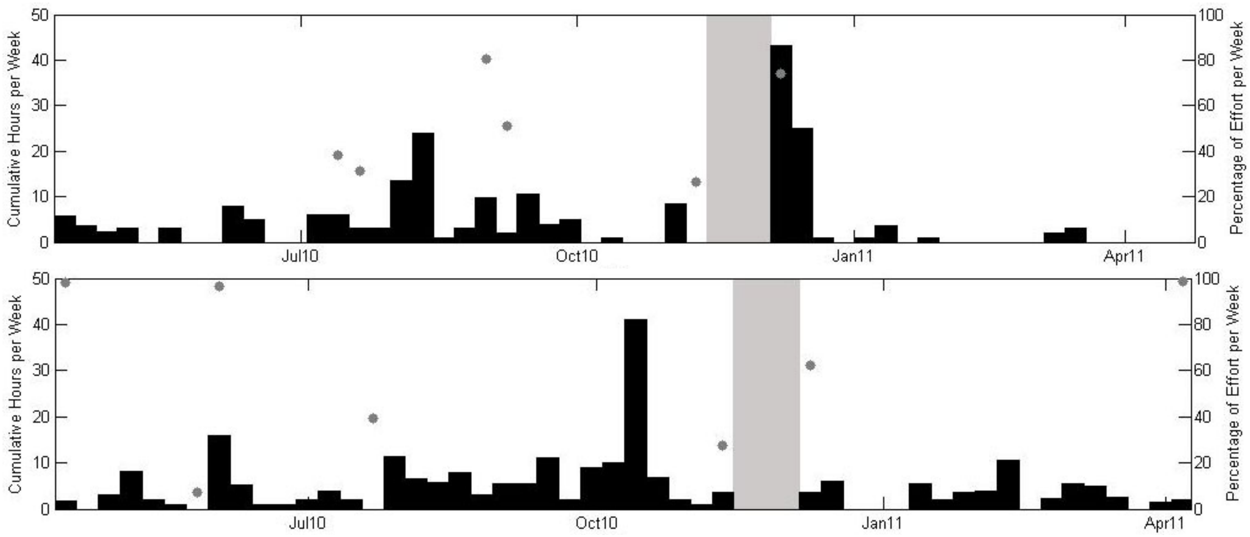

Figure 62. Weekly hours with explosions at sites M (top) and N (bottom) between April 2010 and April 2011. Effort markings are as described in Figure 34.

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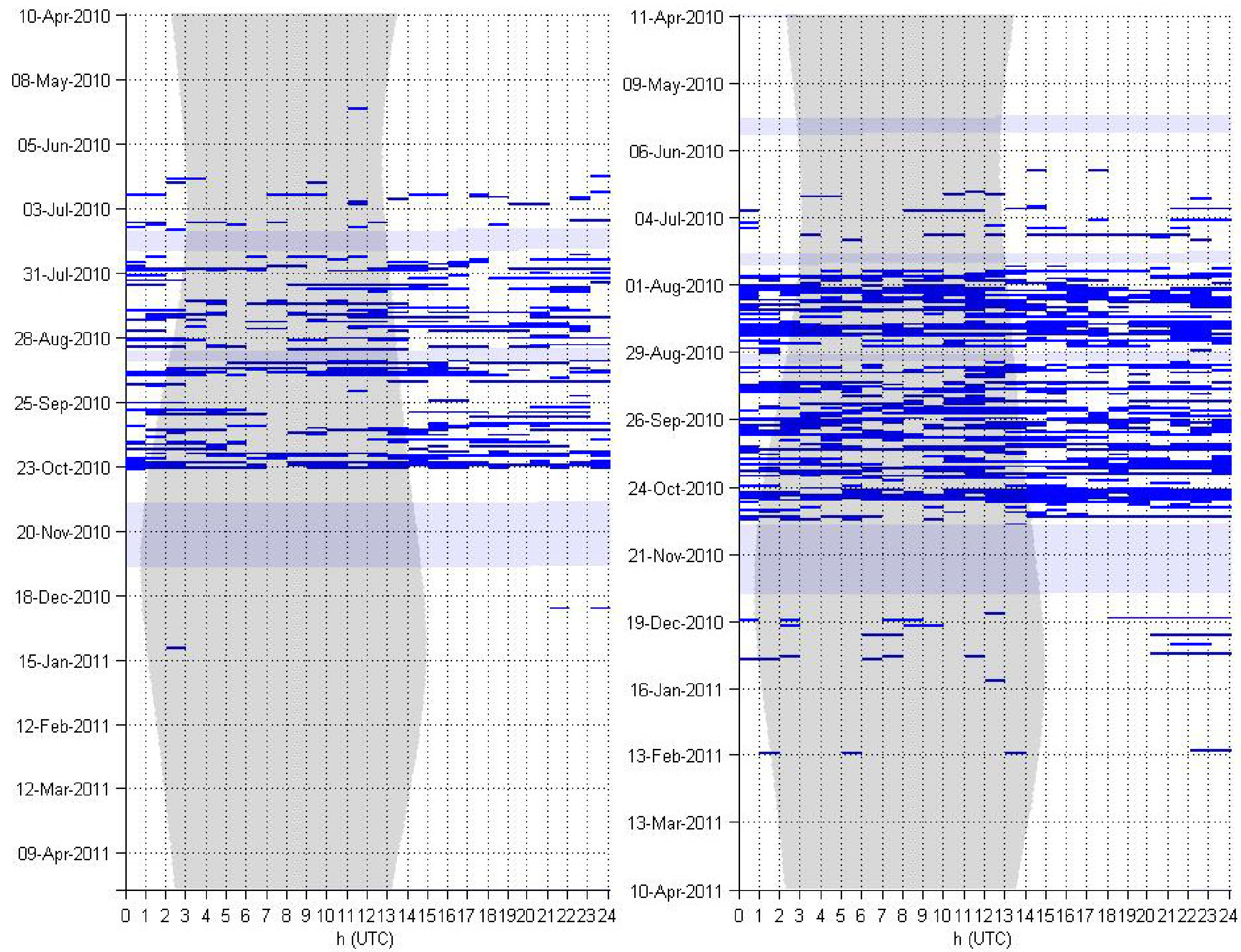
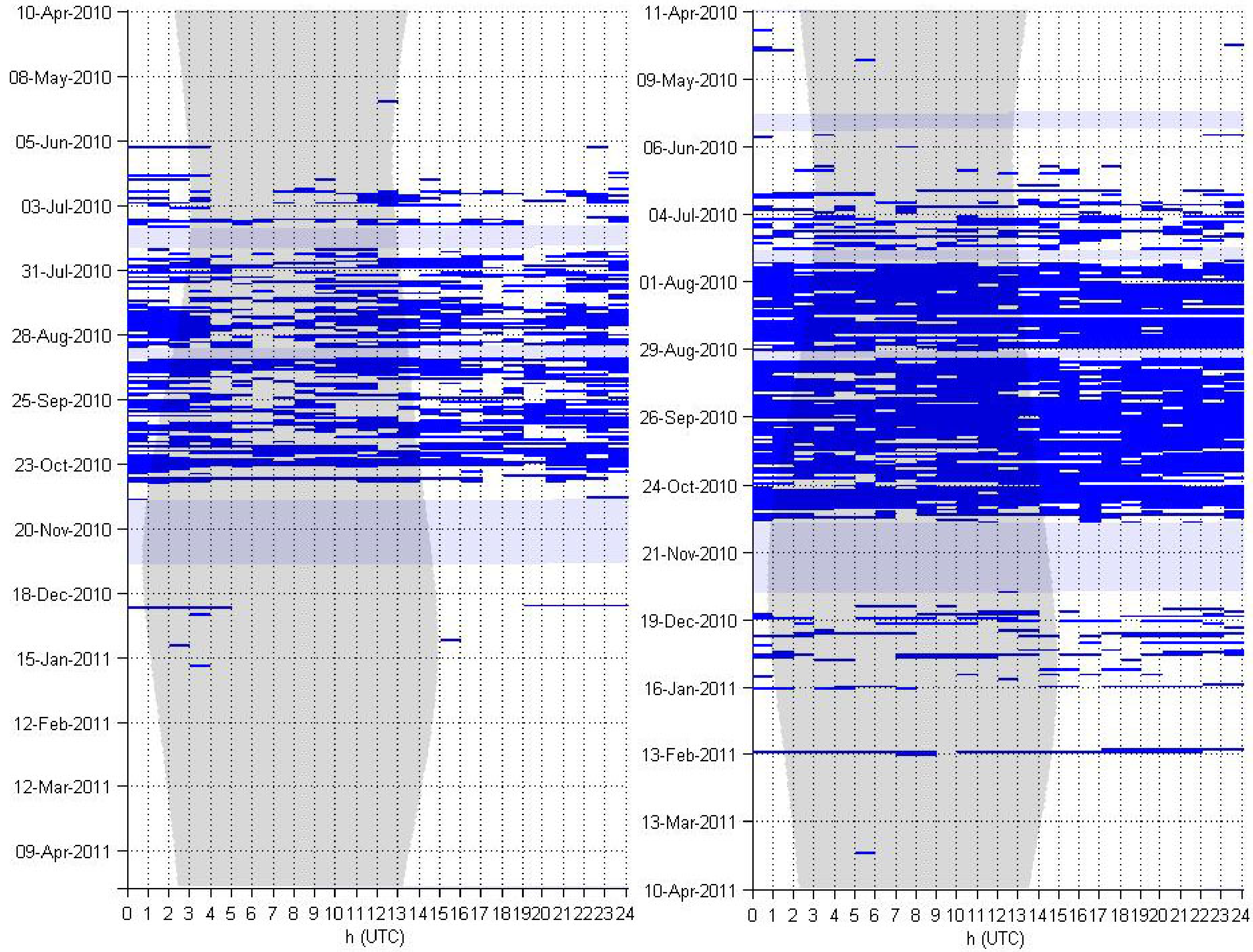
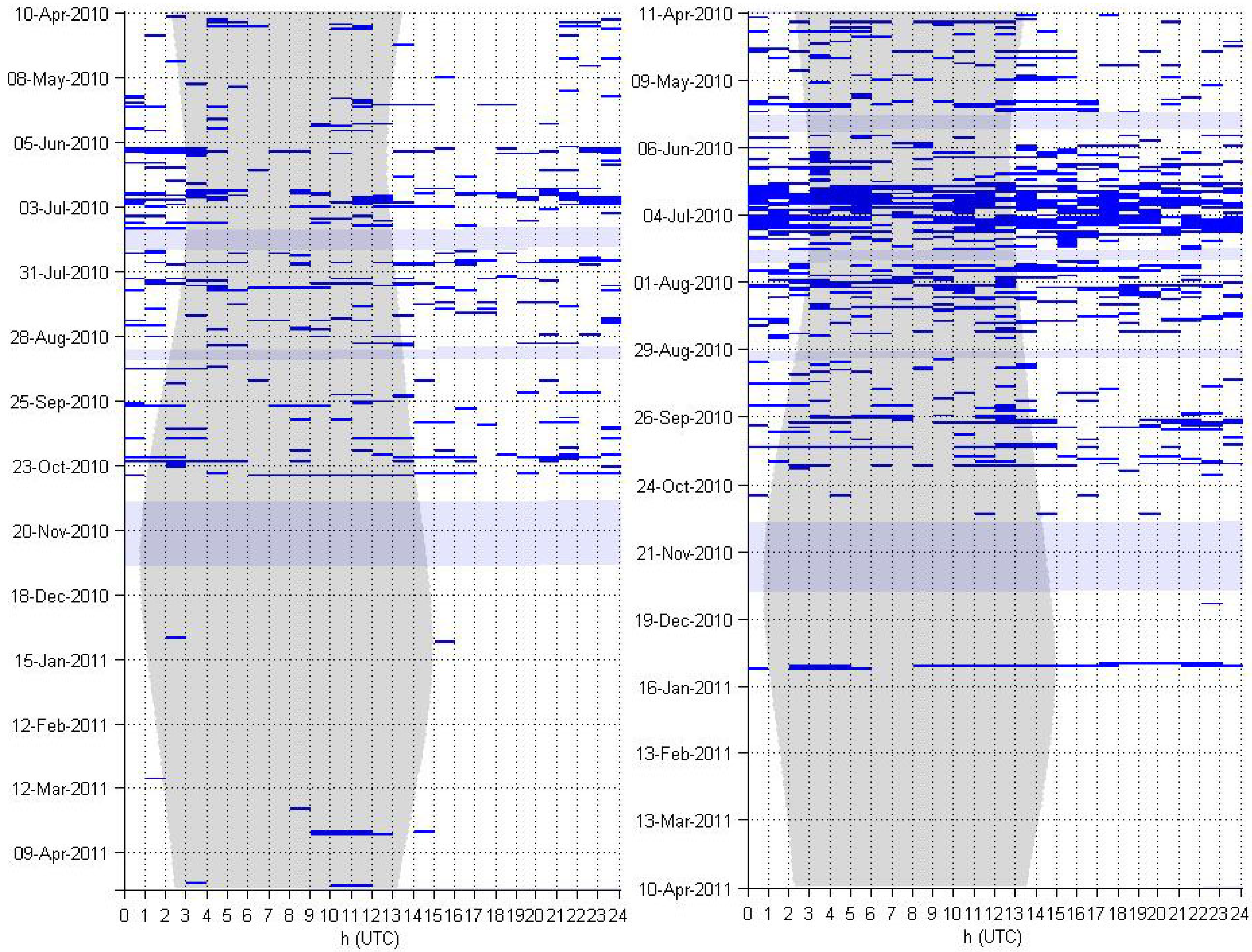
Appendix A - Seasonal/Diel Occurrence Plots



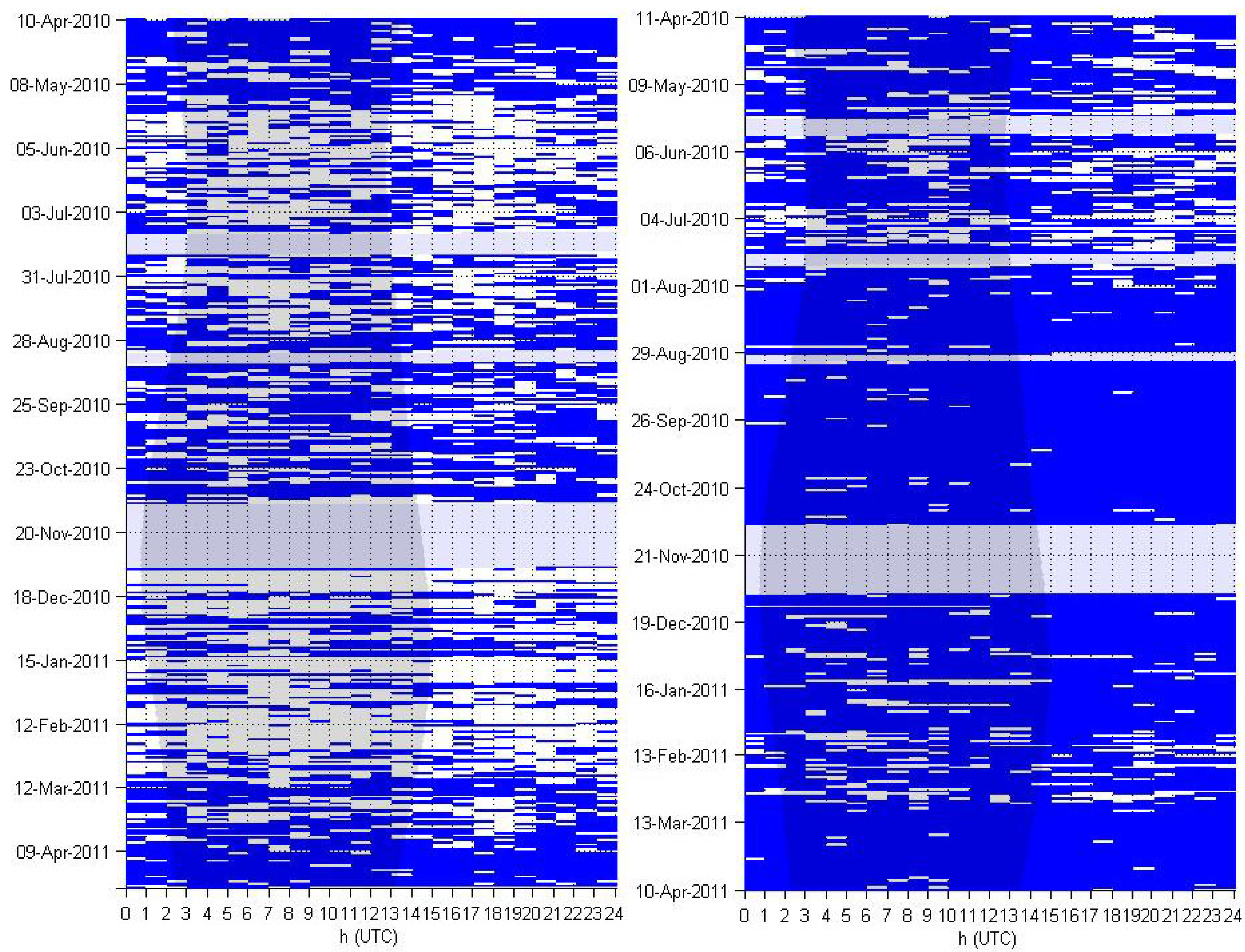
Blue whale – Type A call in hourly bins at sites M (left) and N (right)



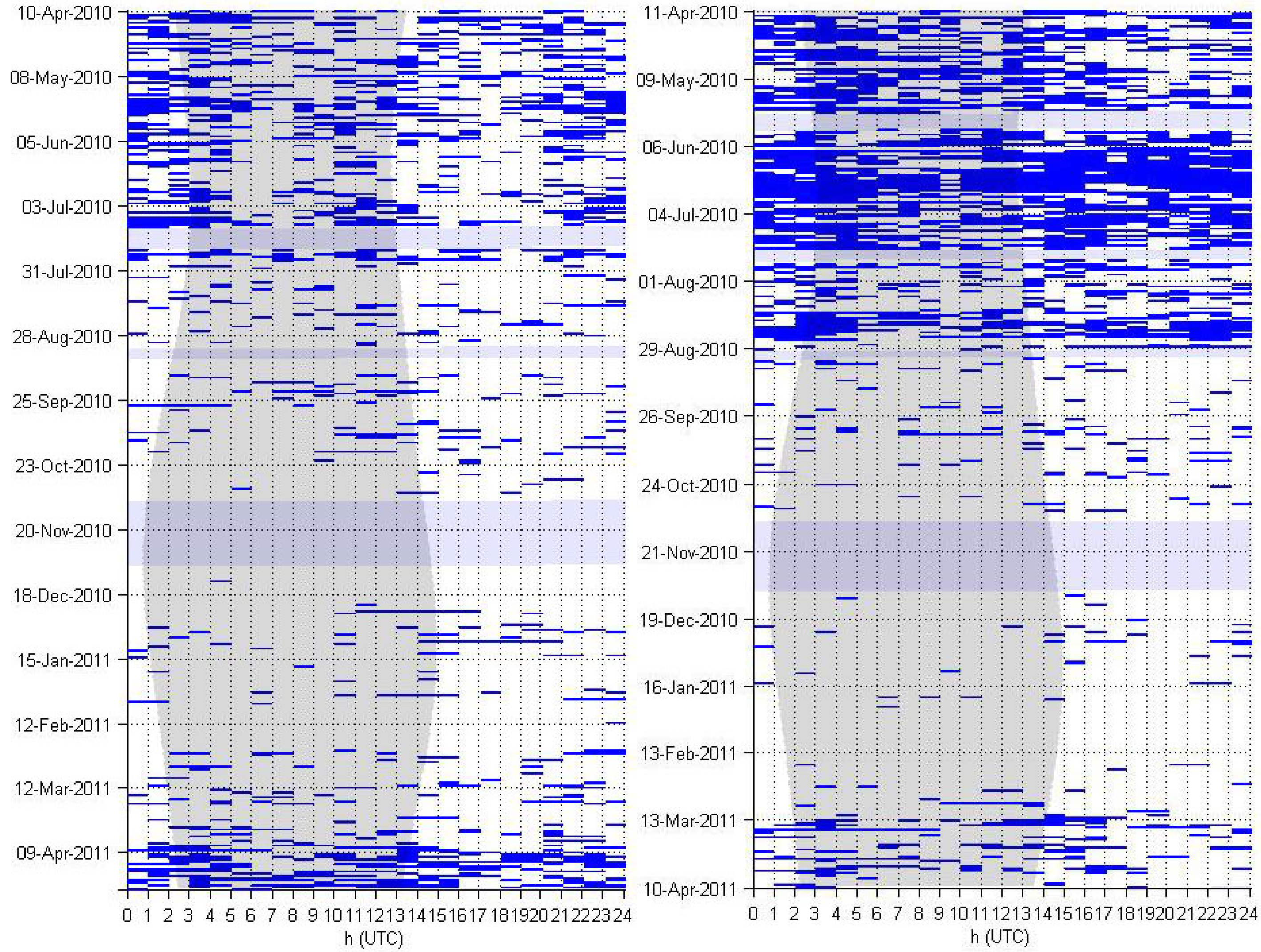
Blue whale – Type B call in hourly bins at sites M (left) and N (right)



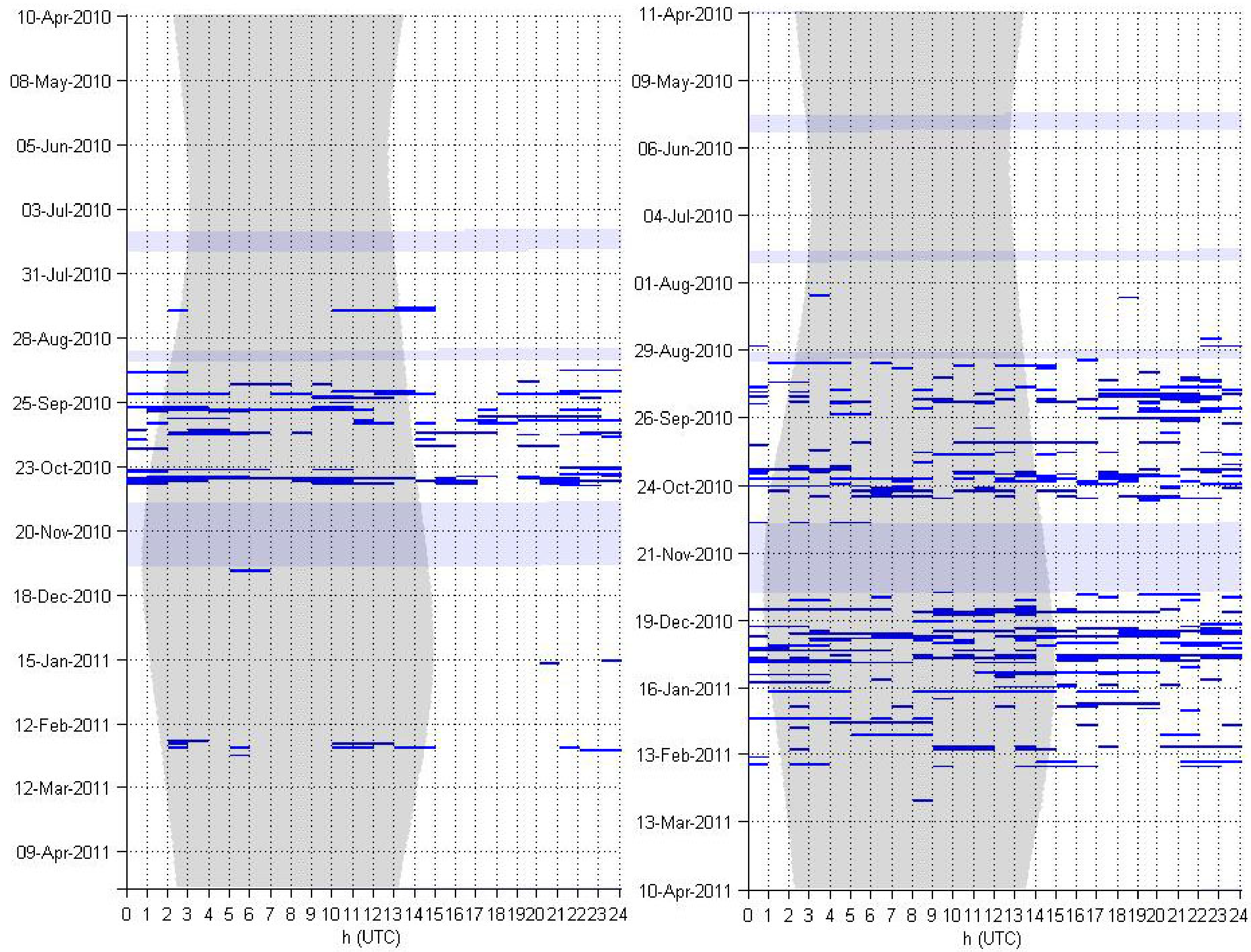
Blue whale – Type D call in hourly bins at sites M (left) and N (right)



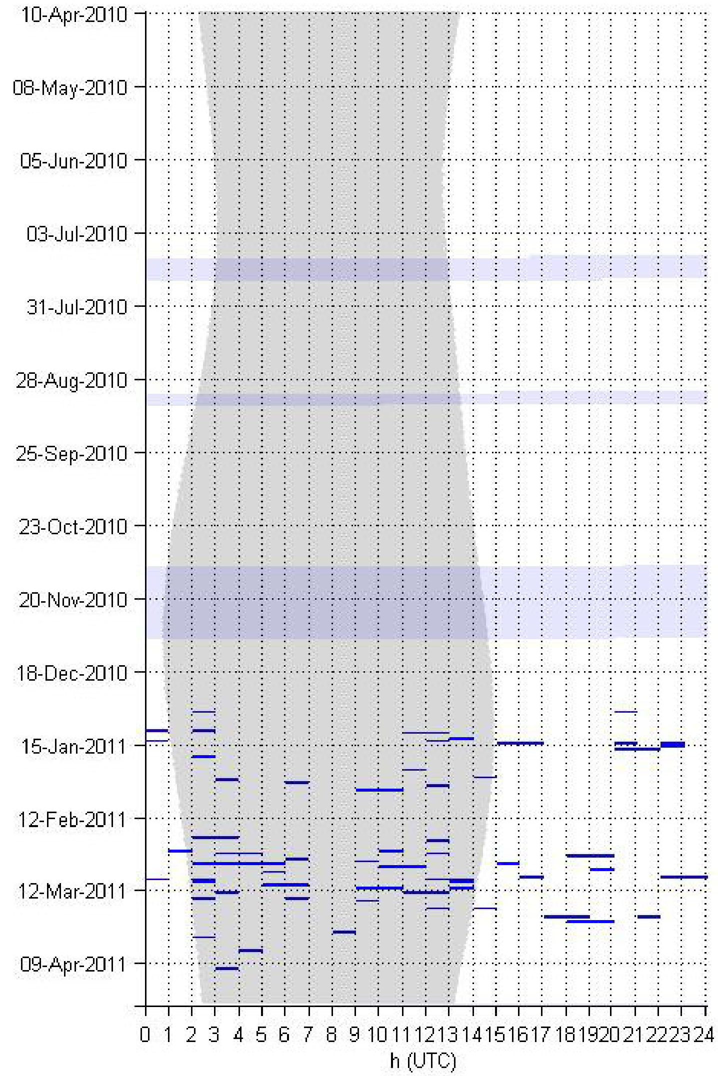
Fin whale – 20 Hz call in hourly bins at sites M (left) and N (right)



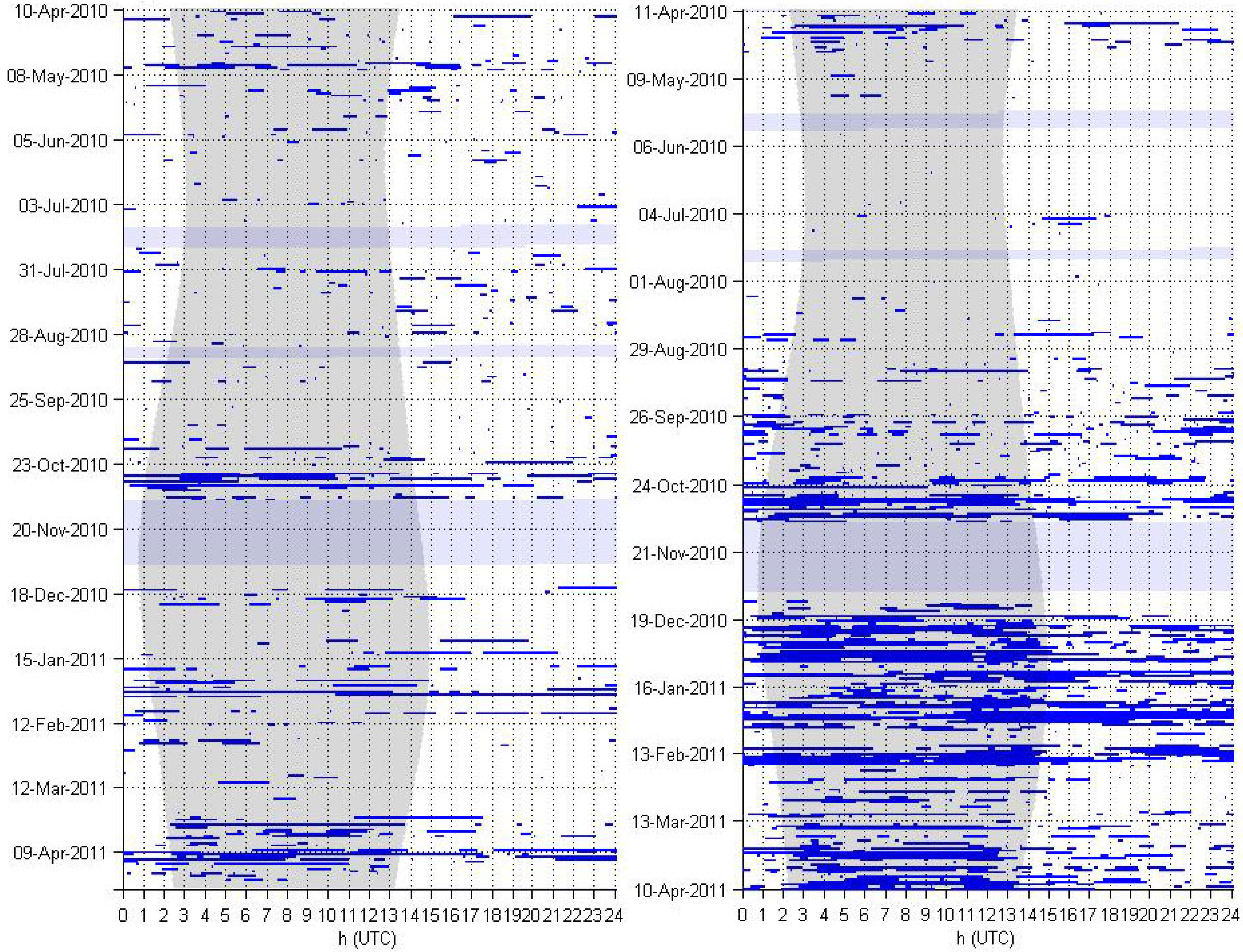
"50 Hz" whale – 50 Hz call in hourly bins at sites M (left) and N (right)



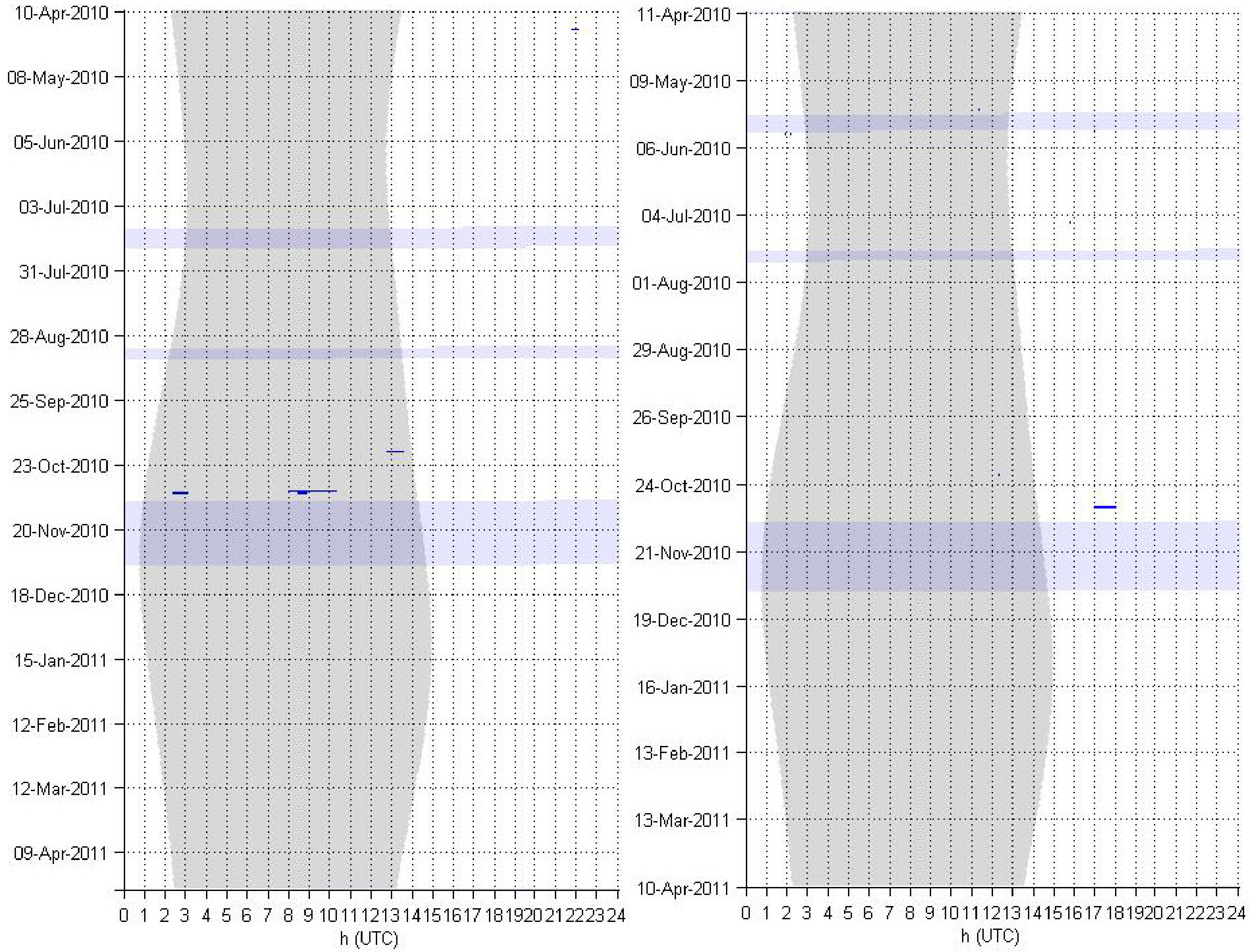
Bryde's whale – Be4 call in hourly bins at sites M (left) and N (right)



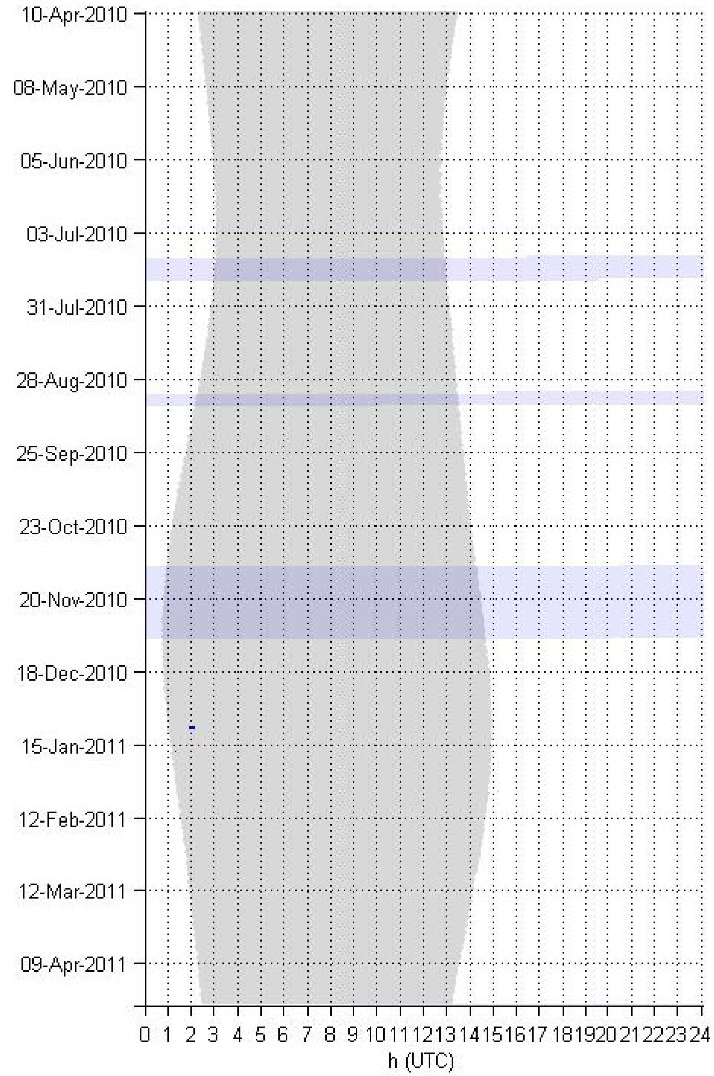
Gray whale – All call types in hourly bins at site M. No gray whale calls were detected at site N



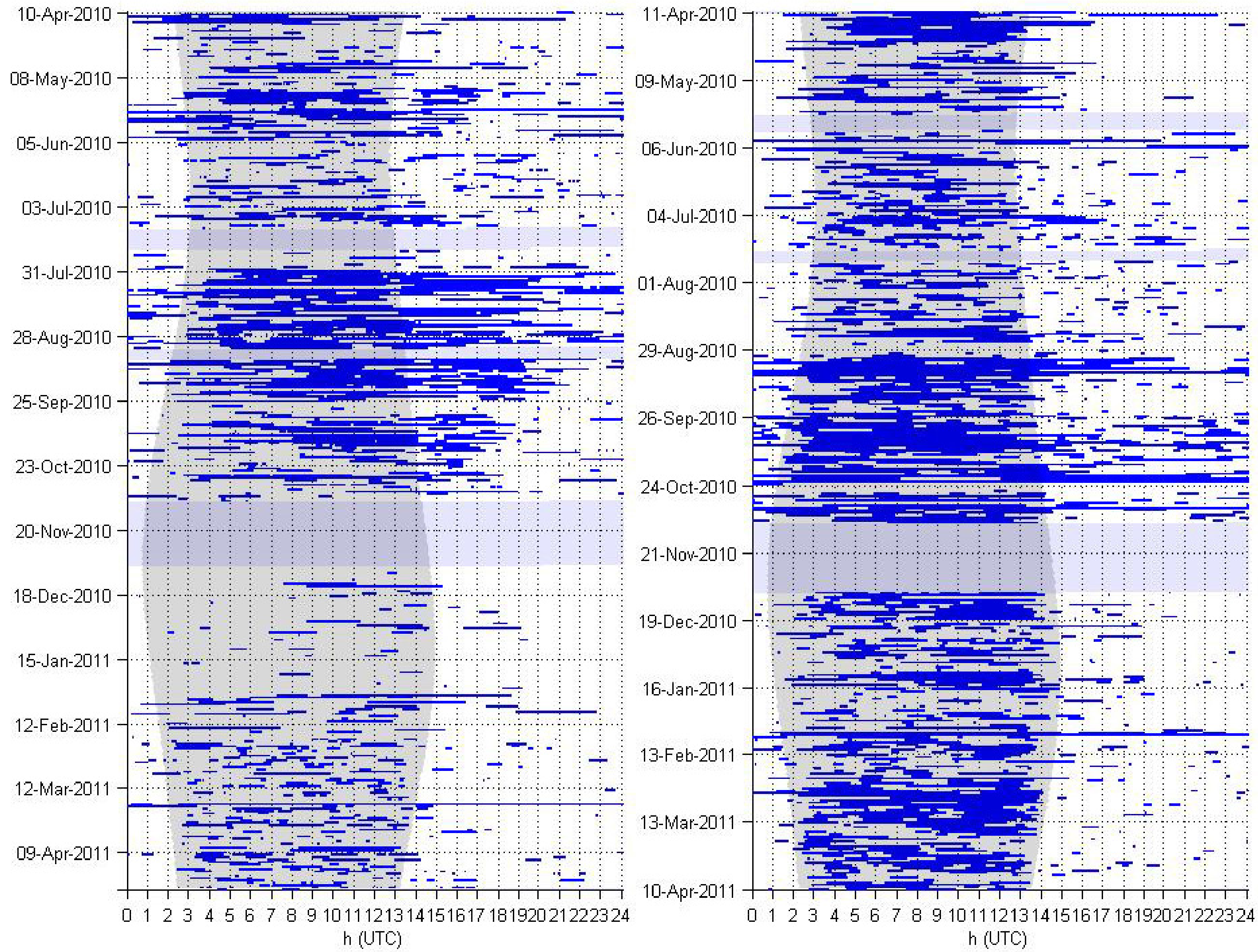
Humpback whale – Song and non-song calls in one-minute bins at sites M (left) and N (right)



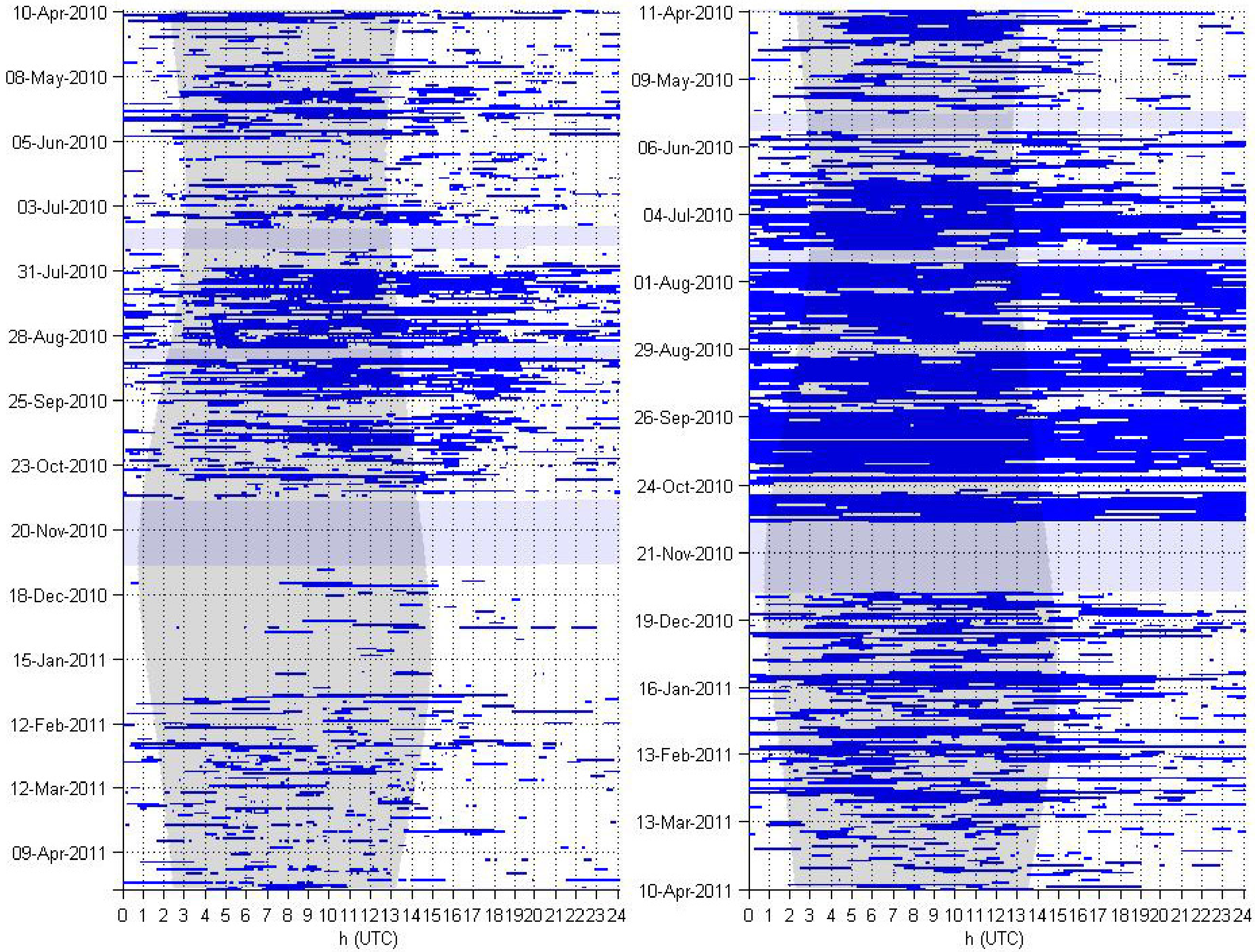
Minke whale – Boings in one-minute bins at sites M (left) and N (right)



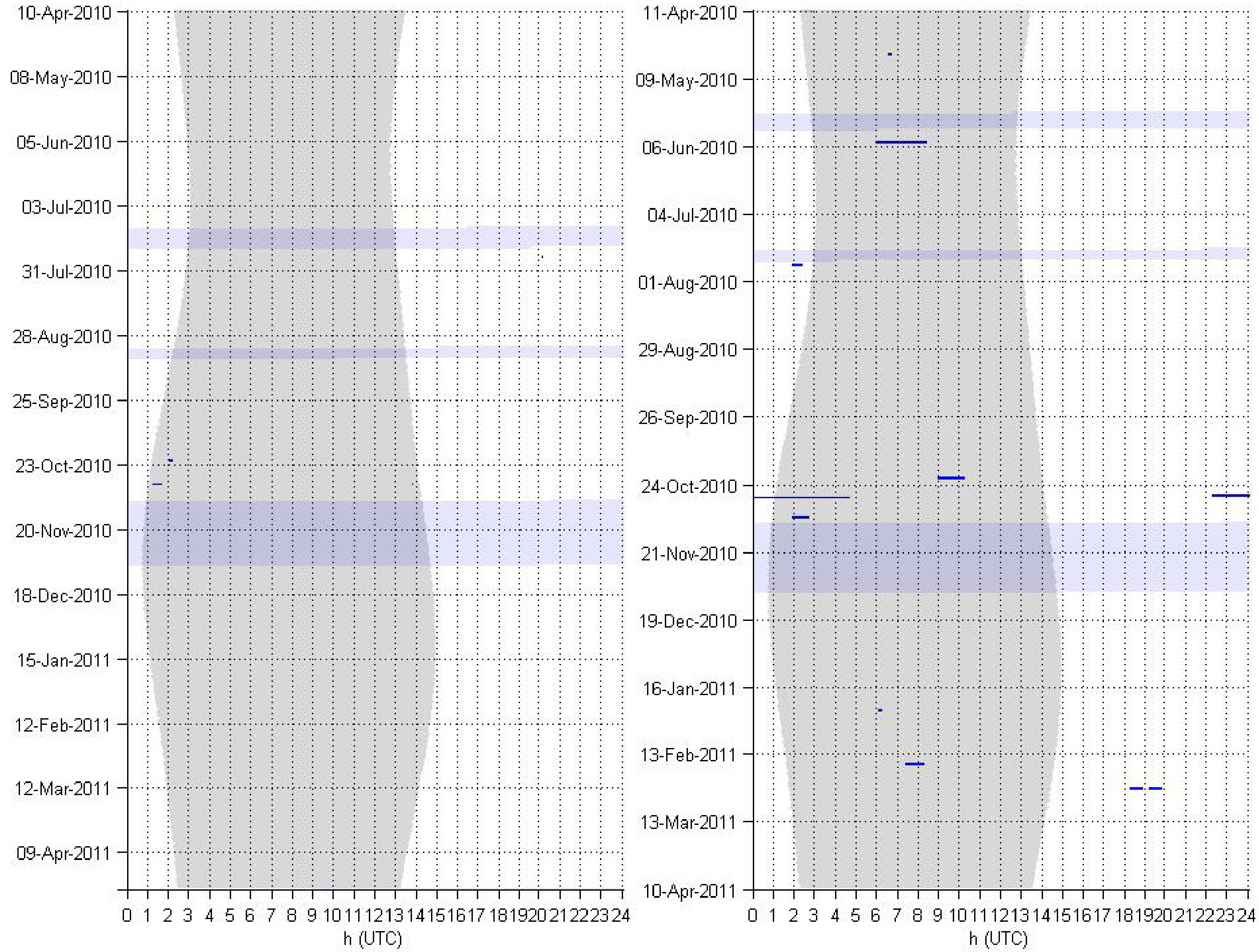
Pinnipeds – Barks in one-minute bins at site M. No pinniped barks were detected at site N.



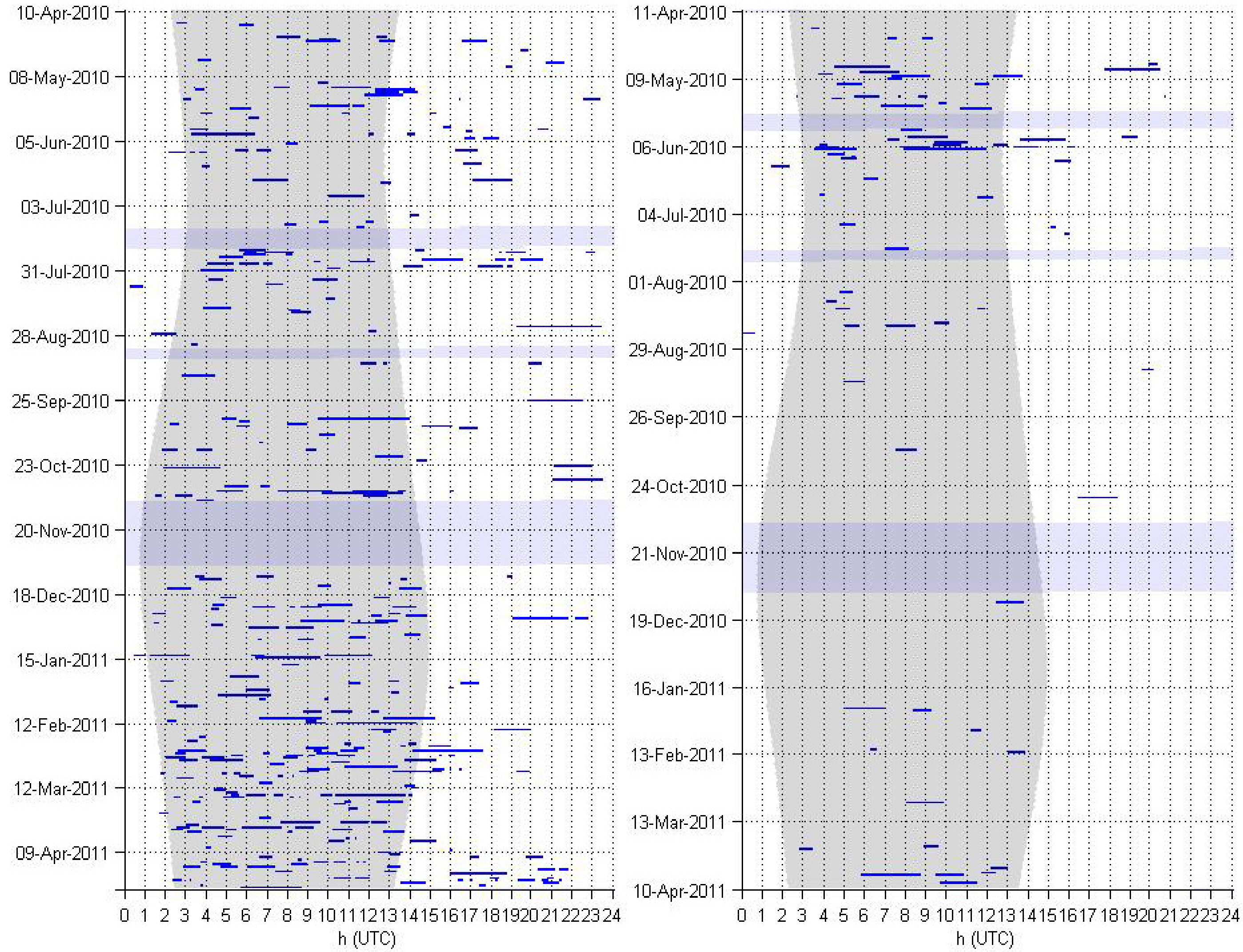
Unidentified Dolphin –Echolocation clicks in one-minute bins at sites M (left) and N (right).



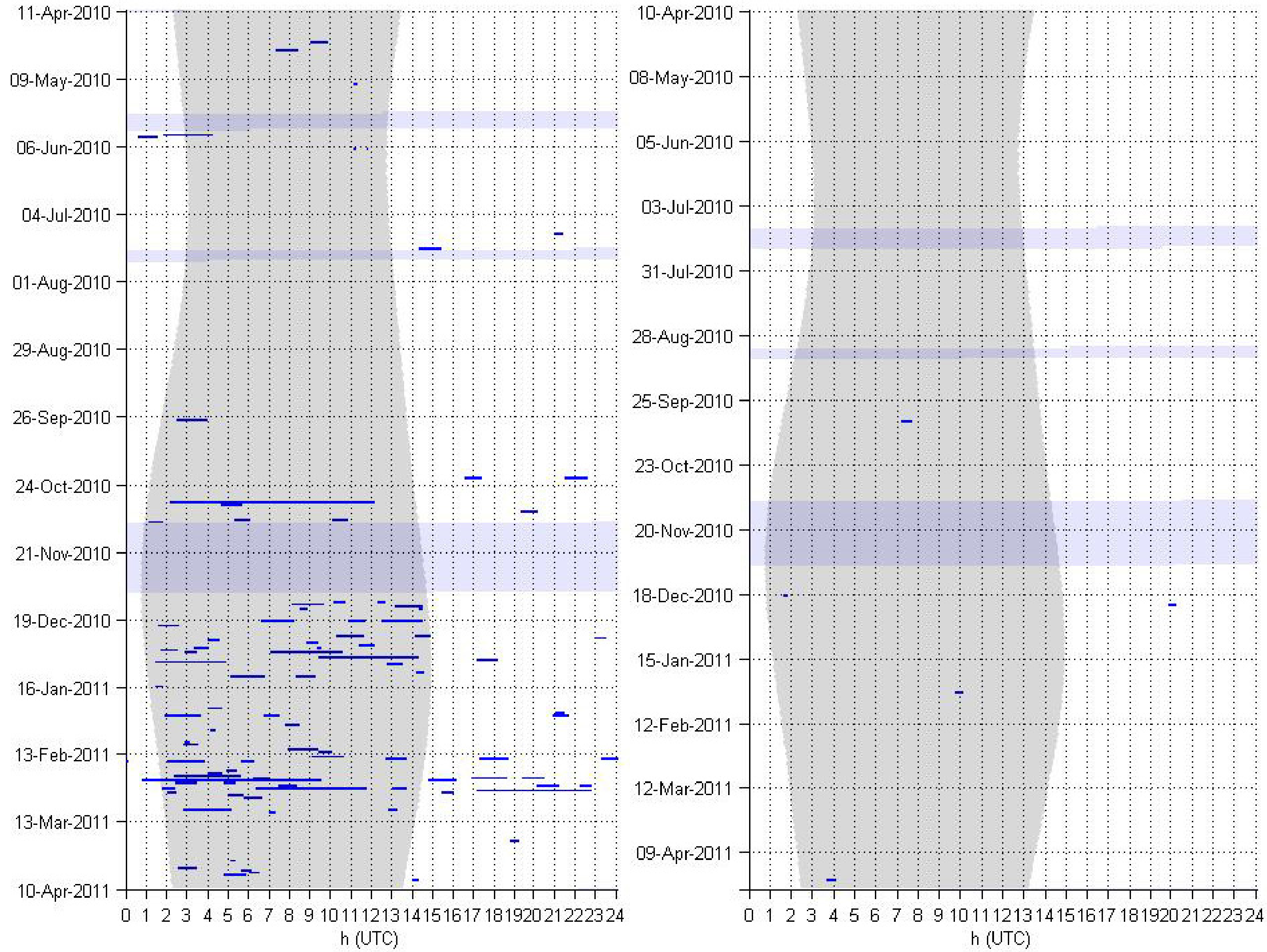
Unidentified Dolphin – Whistles in one-minute bins at sites M (left) and N (right).



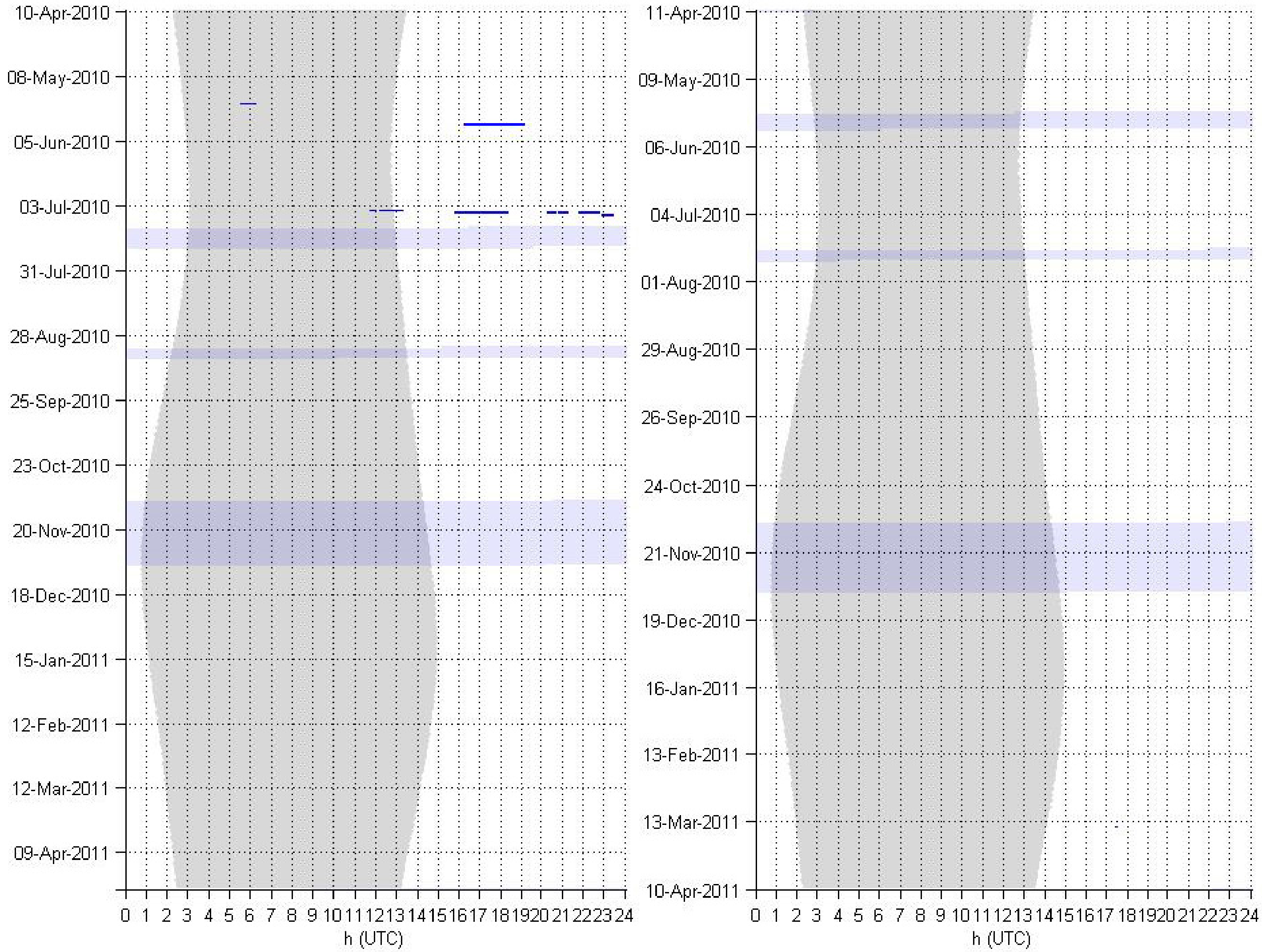
Unidentified Dolphin – Clicks at < 20 kHz in one-minute bins at sites M (left) and N (right).



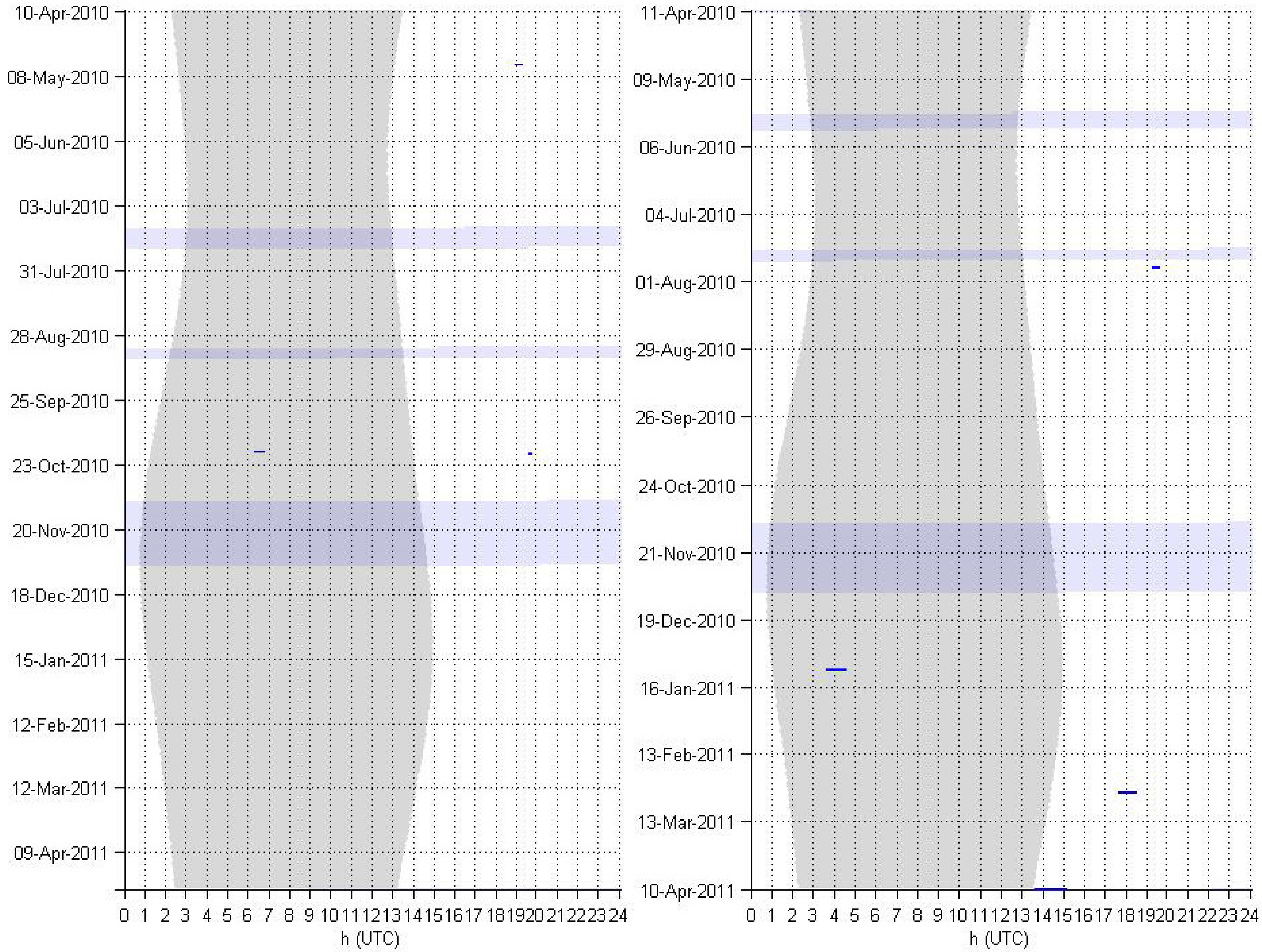
Risso's Dolphin – Echolocation Clicks in one-minute bins at sites M (left) and N (right).



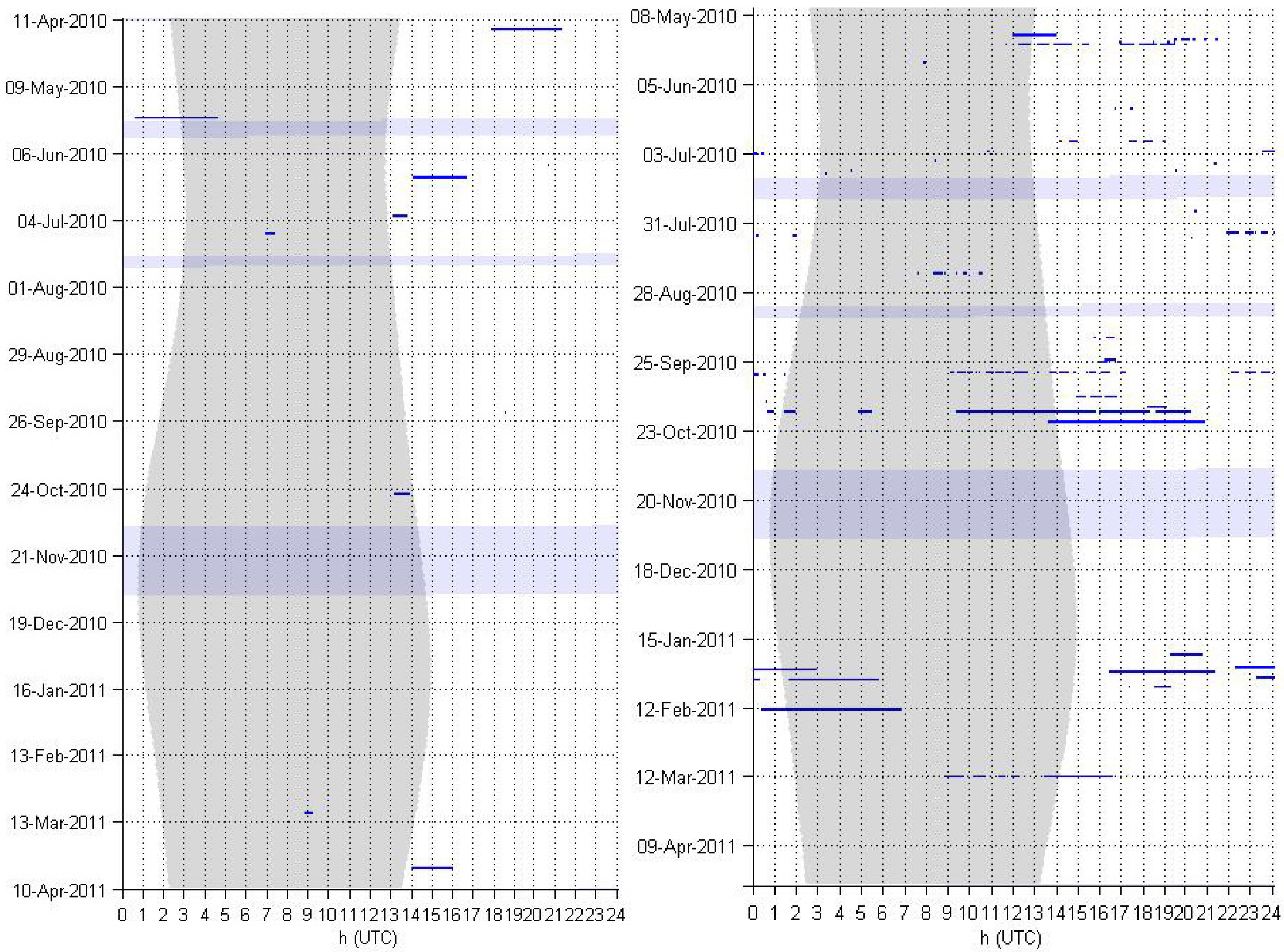
Pacific-White Sided Dolphin – Type A Clicks in one-minute bins at sites M (left) and N (right).



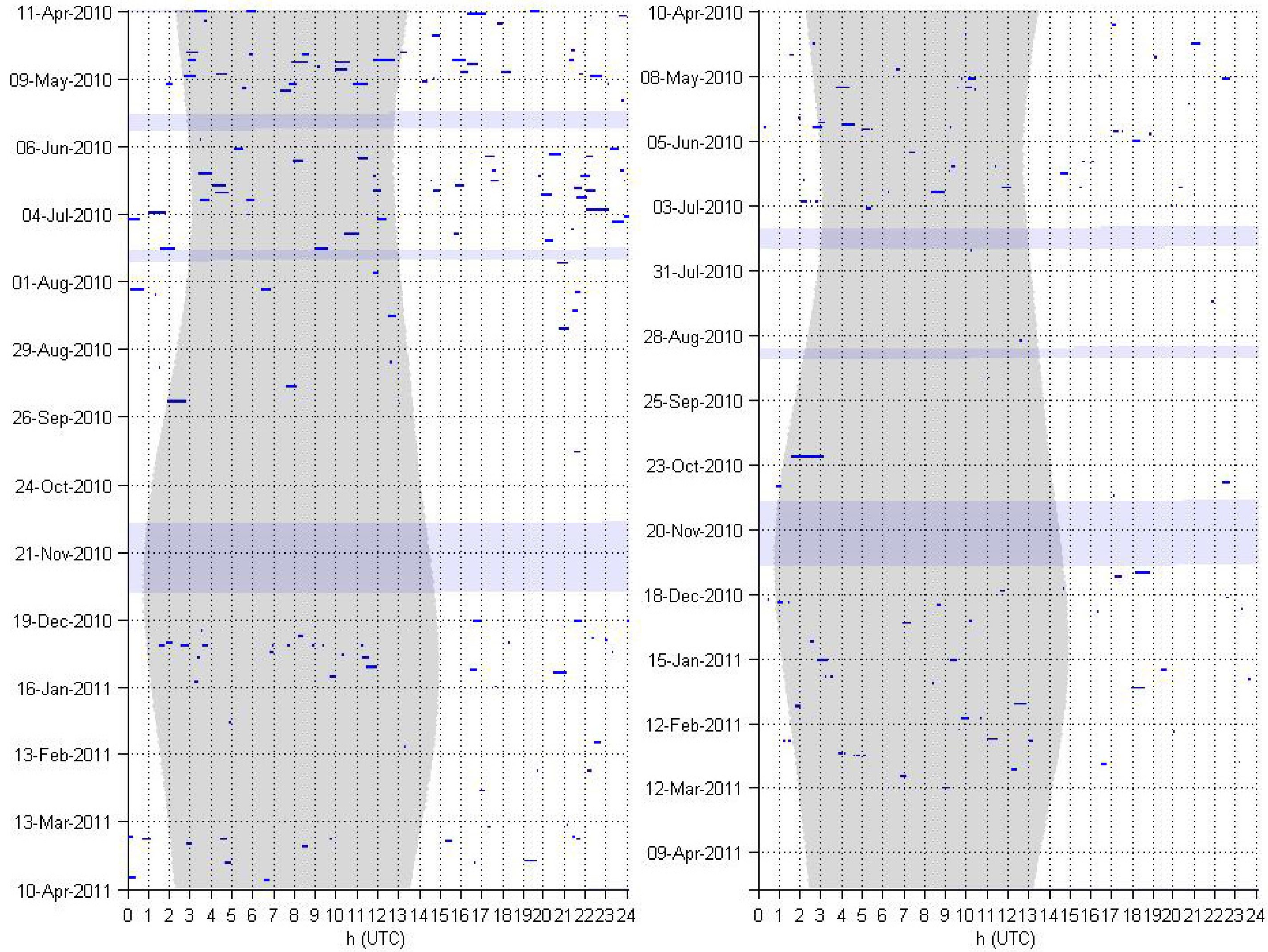
Pacific-White Sided Dolphin – Type B Clicks in one-minute bins at sites M (left) and N (right).



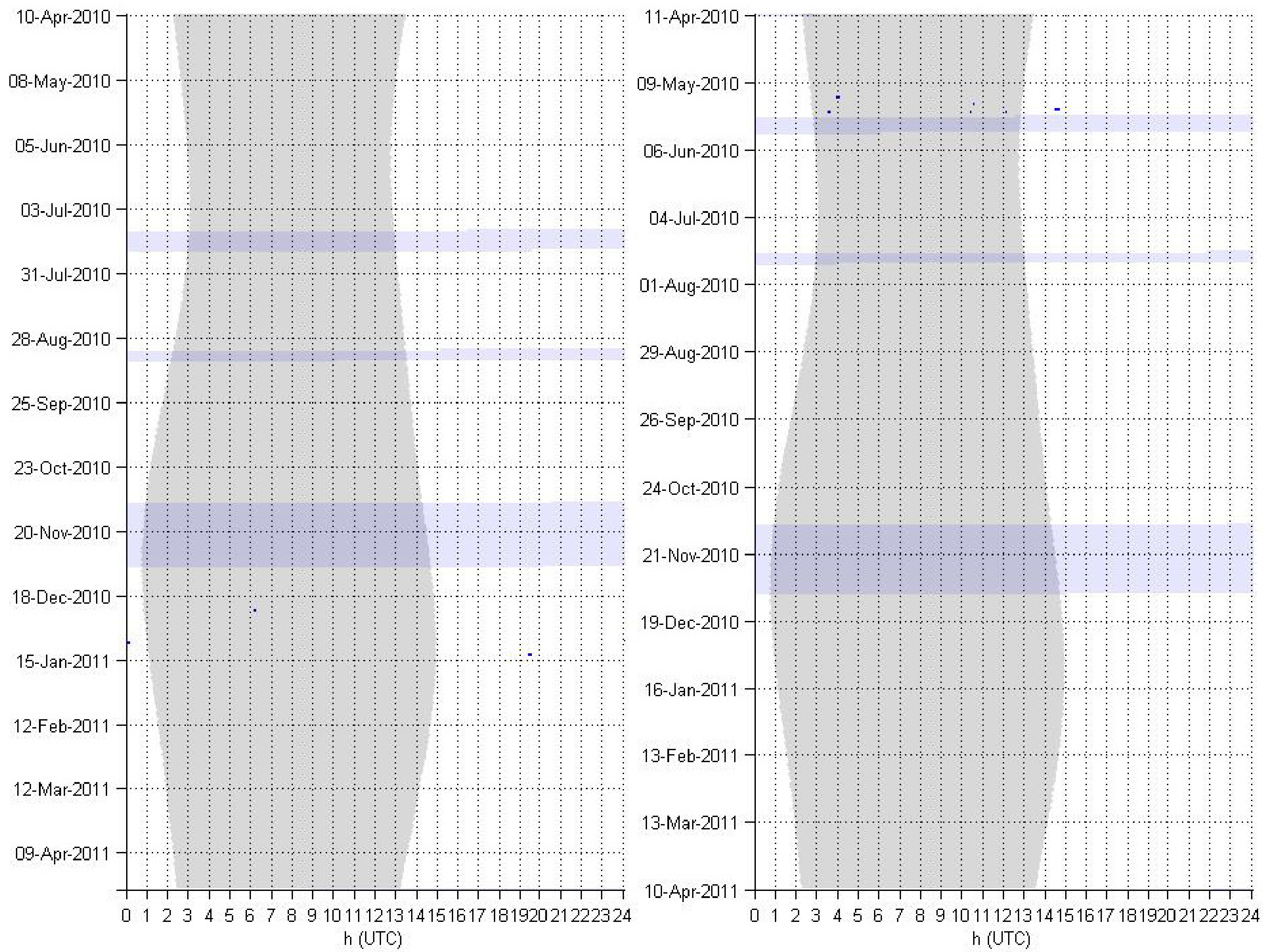
Killer Whale – Clicks, Pulses, Ultrasonic Whistles in one-minute bins at sites M (left) and N (right).



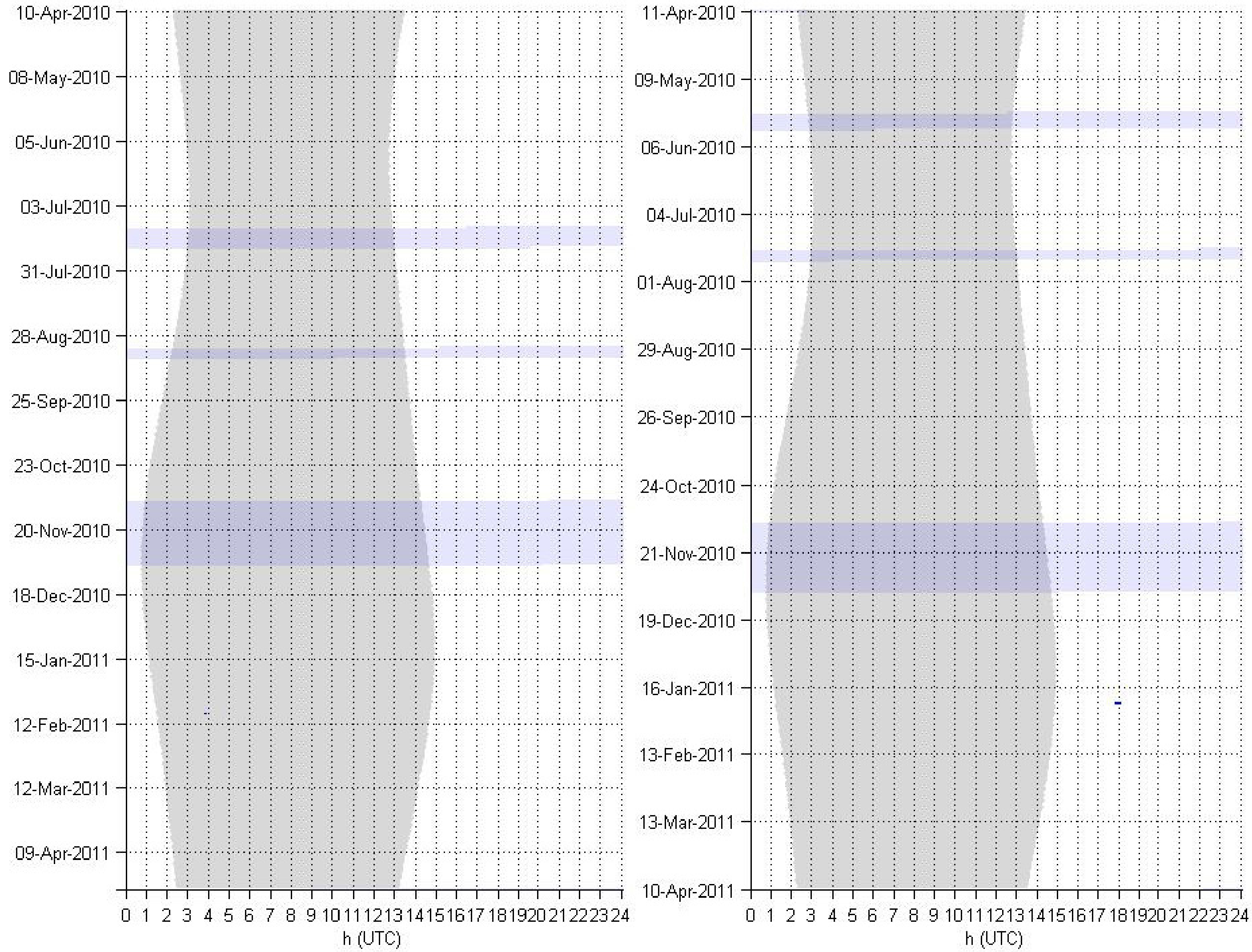
Sperm Whale – Echolocation Clicks in one-minute bins at sites M (left) and N (right).



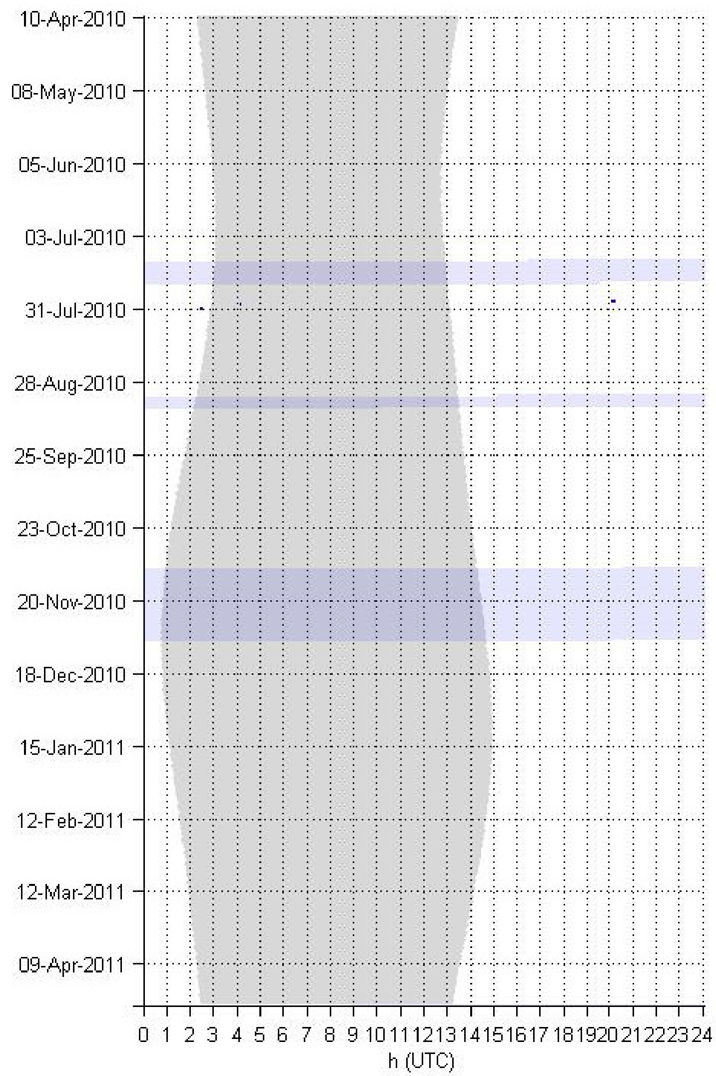
Cuvier's Beaked Whale - Frequency-Modulated Pulses (40 kHz peak frequency) in one-minute bins at sites M (left) and N (right).



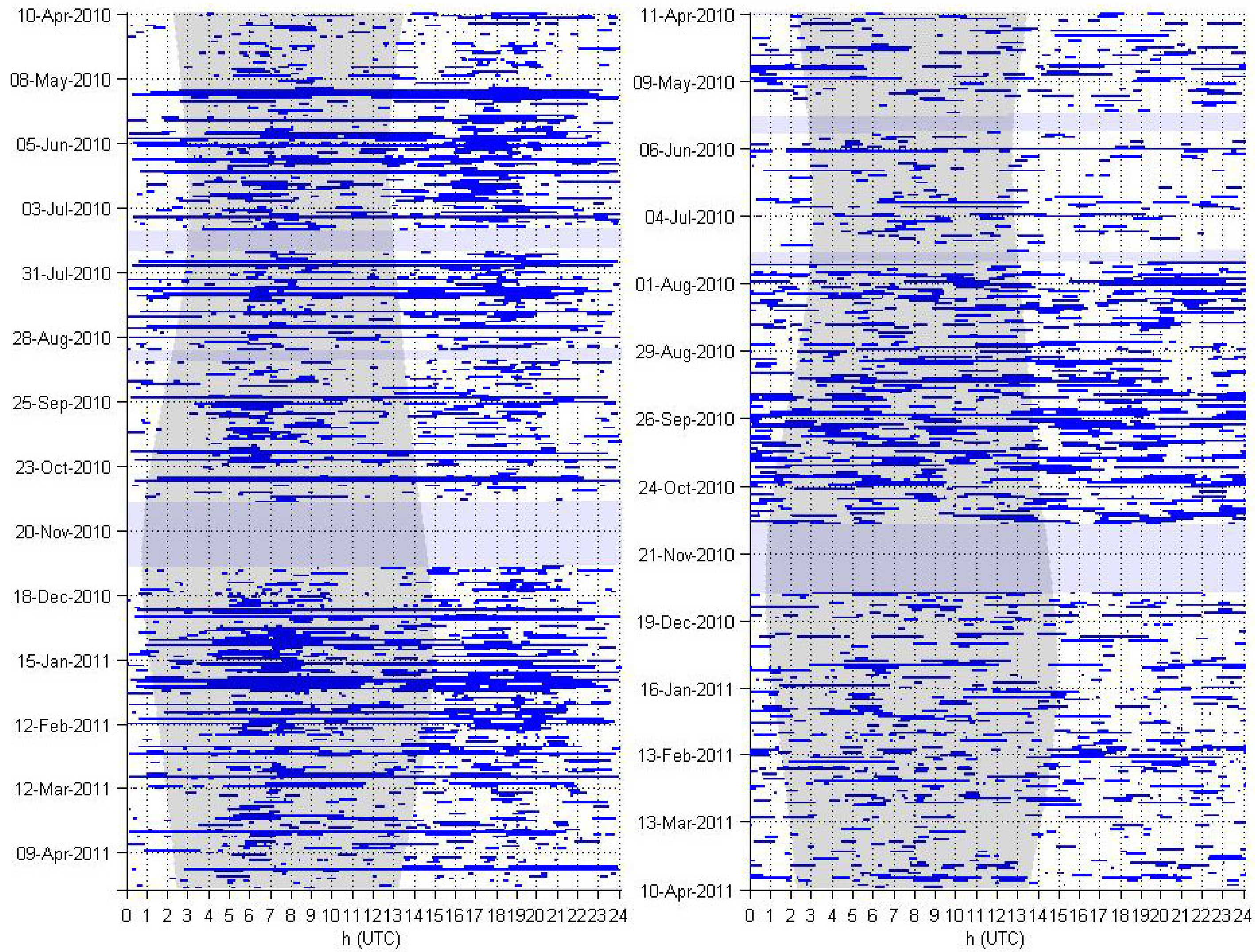
Baird's Beaked Whale – Frequency-Modulated Pulses (15 kHz Peak Frequency), Echolocation Clicks (30, 50 kHz Energy Bands) in one-minute bins at sites M (left) and N (right).



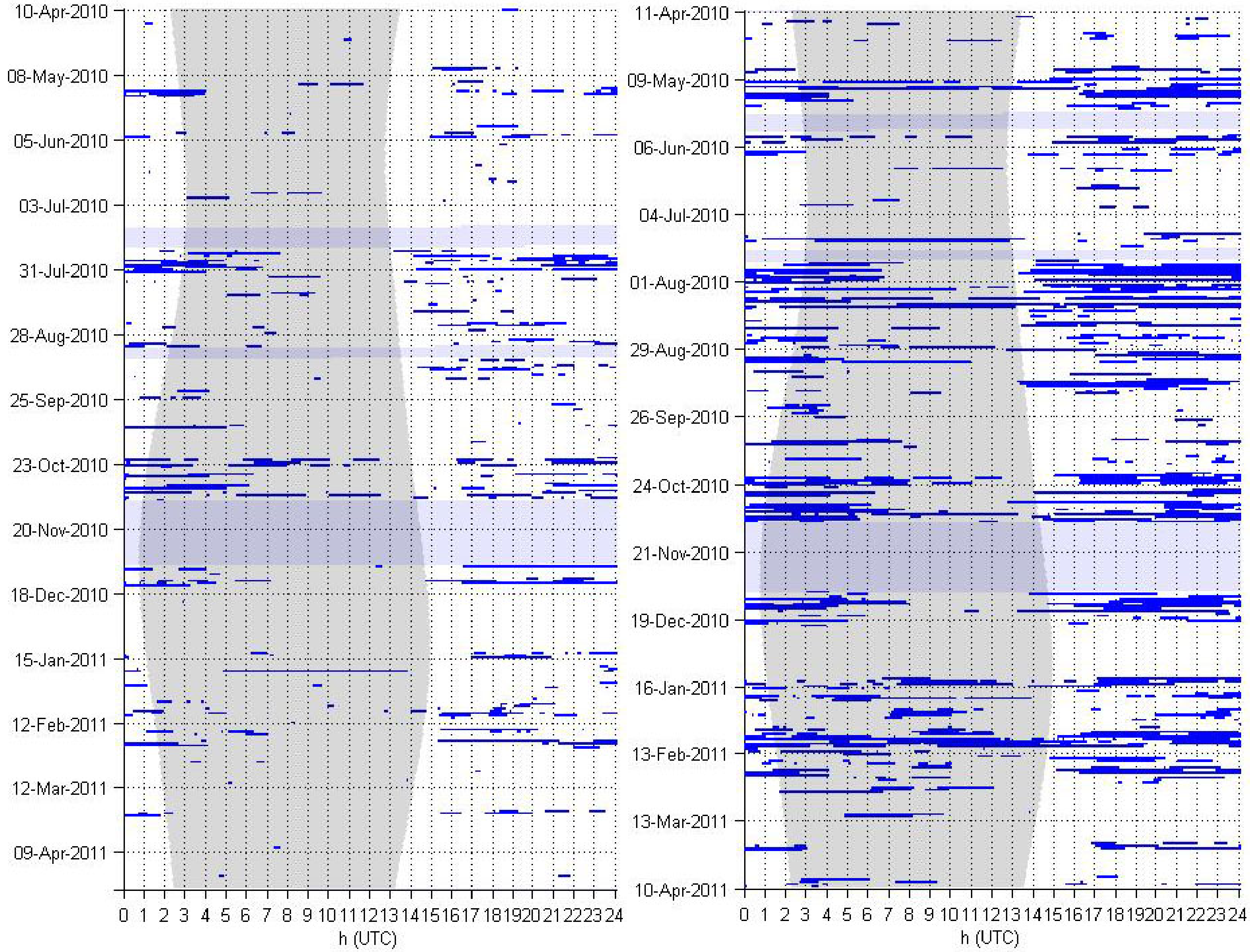
Unidentified Beaked Whale – Frequency-Modulated Pulses with 50 kHz Peak Frequency at Site M (left) and 43 kHz Peak Frequency at Site N (right).



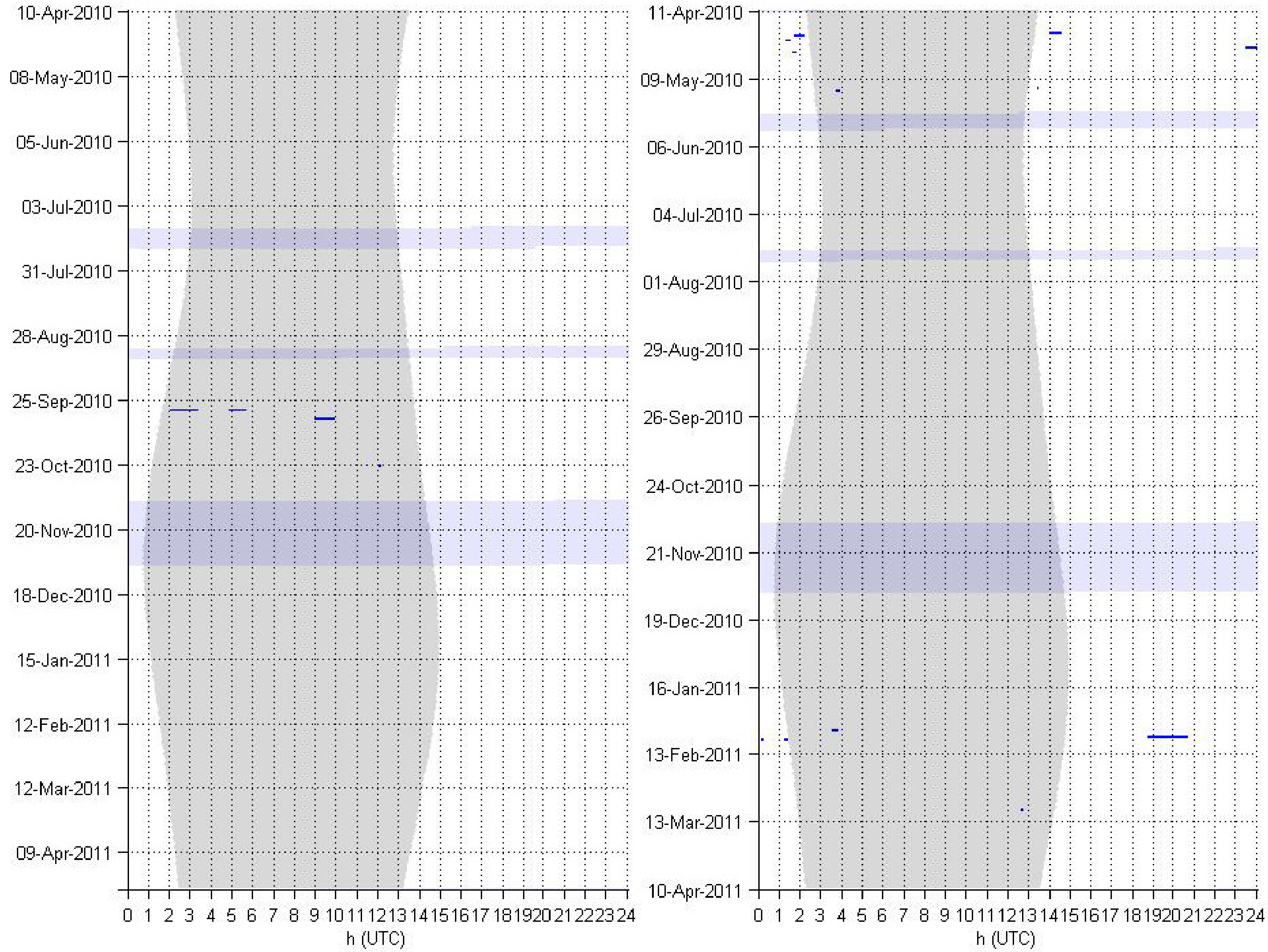
Unidentified Beaked Whale – Frequency-Modulated Pulses by Stejneger's beaked whale at Site M



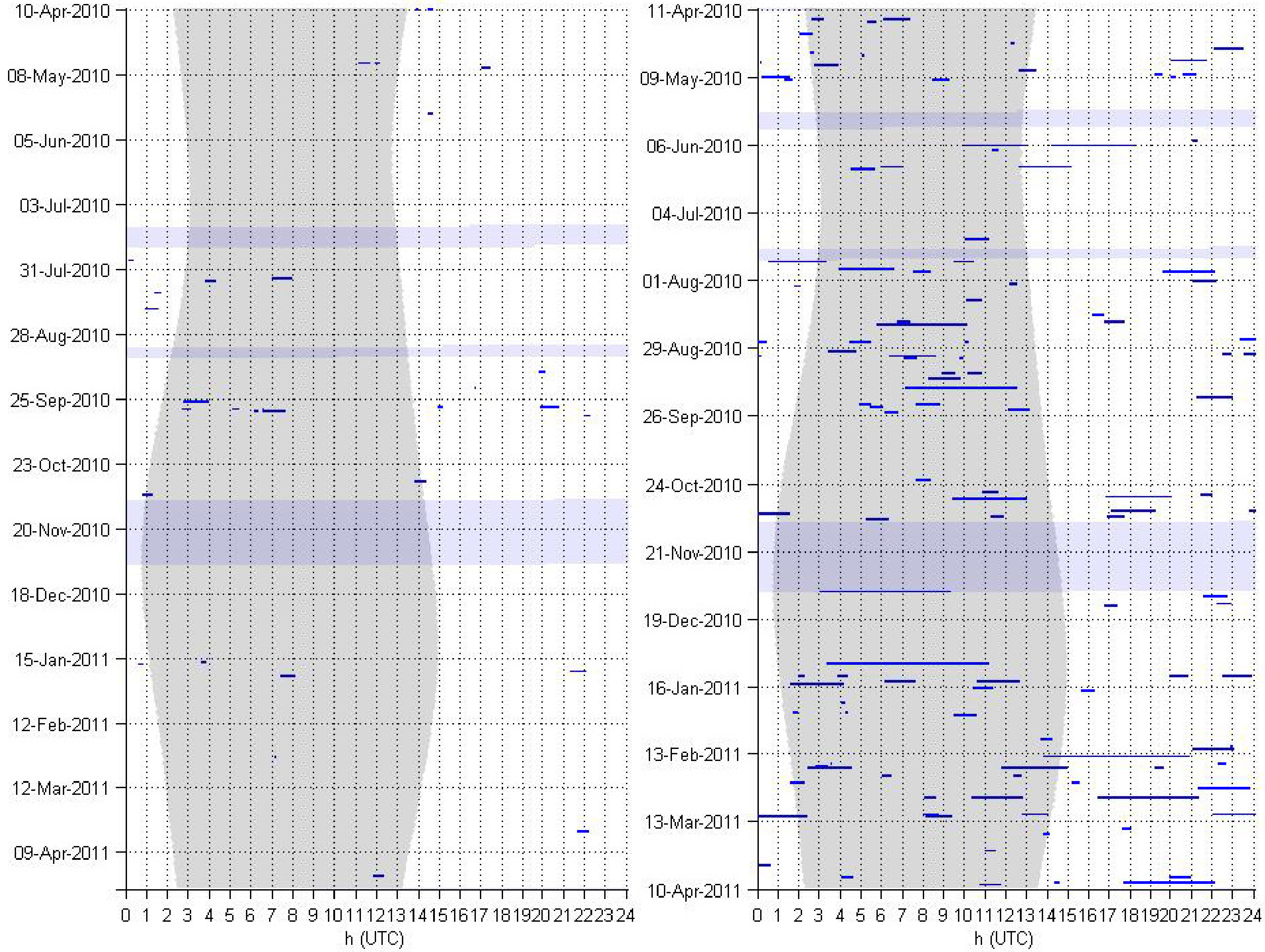
Broadband ship noise – presence in one-minute bins at sites M (left) and N (right)



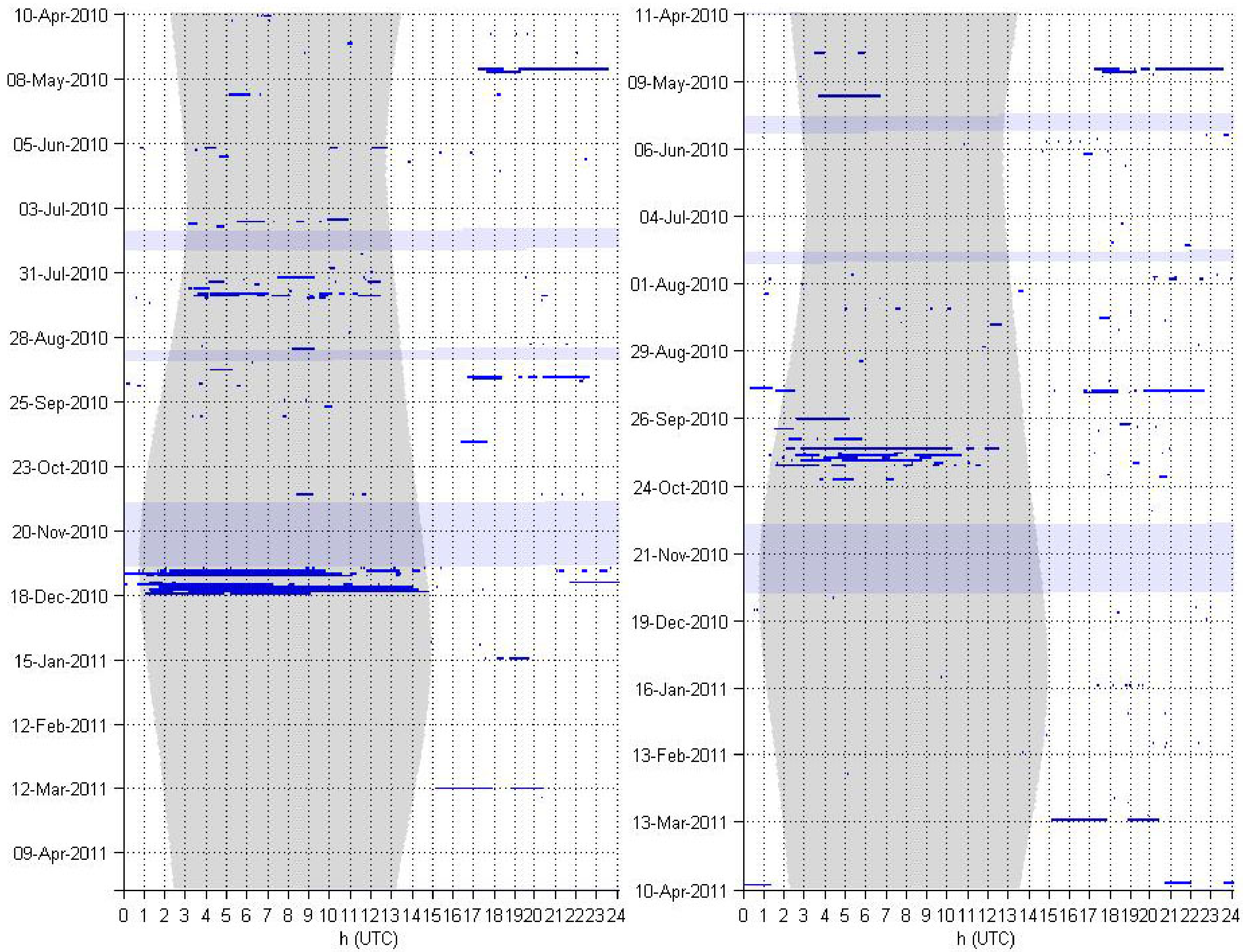
Mid-frequency active sonar – presence in one-minute bins at sites M (left) and N (right)



High Frequency Active Sonar – Upsweep Pulses (20-30 kHz) in One-Minute Bins at Sites M (left) and N (right).



Echosounder Pings – Various Frequency Pings in One-Minute Bins at Sites M (left) and N (right).



Explosions – Presence in hourly bins at sites M (left) and N

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APPENDIX D. Navy Research Funded Year Three Project Reports

- Distribution and Demographics of Marine Mammals in SOCAL through Photo-Identification, Genetics, and Satellite Telemetry (Cascadia Research Collective)Small boat based marine mammal surveys in Southern California: Report of Results for August 2009 - July 2010 (Scripps Institute of Oceanography and Southwest Fisheries Science Center)
- California Cooperative Oceanic Fisheries Investigation (CalCOFI) field cruises in Southern California (Scripps Institute of Oceanography)

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DISTRIBUTION AND DEMOGRAPHICS OF MARINE MAMMALS IN SOCAL THROUGH PHOTO-IDENTIFICATION, GENETICS, AND SATELLITE TELEMETRY:

A summary of surveys conducted 15 June 2010 – 24 June 2011

Cascadia Research Collective
non-profit research and education since 1979

Report prepared by:
Erin A. Falcone and Gregory S. Schorr
Cascadia Research Collective
Waterstreet Building
218½ W. 4th Avenue
Olympia, Washington 98501

Annual progress report (year 1 of 3) for Grant N00244-10-1-0050 through the Naval Postgraduate School
Submitted 01 July 2011

INTRODUCTION

The U.S. Navy manages the Southern California Range Complex (SOCAL), a collection of nearshore and offshore training area which includes much of the waters from Santa Barbara, CA south to Northern Baja California, MEX and extending several hundred miles west. It is among the most heavily used tactical training areas in the world, and is used for a variety of aerial, surface, and subsurface exercises. The Southern California Offshore Range (SCORE) is a subset of complexes within SOCAL centered on San Clemente Island. It in turn includes the Southern California Anti-submarine Warfare Range (SOAR), a focal area for exercises involving MFAS in the San Nicolas Basin, extending approximately 60km west of the island[12]. SOCAL includes a wide variety of marine habitats, and subsequently is home to a high diversity of cetacean species year-round, though with some seasonal fluctuations. While the more coastally-distributed species and populations within the region have generally been well-studied; the distribution, demographics, and behavioral patterns of cetaceans in the outer waters of the Bight are much less well-known. Operations in this region have been subject to rising environmental scrutiny in recent years, as an increasing number of unusual cetacean stranding events have occurred in association with the use of MFAS and other anthropogenic sound sources in other parts of the world. Subsequently, detailed knowledge of how cetaceans use the outer waters of the Southern California, and specifically the waters around SOAR, is critically needed.

Cascadia Research Collective (CRC) began conducting visual surveys at SCORE in August 2006 in collaborations with staff from the Naval Undersea Warfare Center (NUWC), Scripps Institution of Oceanography (SIO), and the Naval Postgraduate School (NPS). The primary objective of these surveys was to provide visual verification of acoustic marine mammal detections on the SOAR

12 http://www.globalsecurity.org/military/facility/socal.htm; accessed 28 June 2011

hydrophone array. NUWC developed a suite of passive acoustic tools to monitor vocal cetacean species using the AUTEC array in the Bahamas, known as Marine Mammal Monitoring on Navy Ranges (M3R) (Moretti et al. 2006). These tests provided data for adapting M3R for use at SOAR, where a much higher density and diversity of vocal species occur. These surveys also provided an opportunity for data collection from a region that had not previously been available to researchers, both due to its remoteness and predominantly rough sea conditions, and also to regular restrictions associated with military operations.

While additional data from all species utilizing the range was of value given the increasing concerns surrounding marine mammals and military activities, the focal species during these surveys were beaked whales. Several species of beaked whales are known to occur along the US West Coast. Of these, Cuvier's beaked whale (*Ziphius cavirostris*) is the most frequently sighted; however sighting rates are too low even for this species to derive reliable population estimates. The animals present along the coasts of California, Oregon, and Washington are currently managed by NMFS as a single stock, estimated at approximately 2,000 individuals as of the most recent stock assessment report (Caretta et al. 2011). While the deep basin of the SOAR range is consistent with habitat used by beaked whales in other parts of the world, the degree to which they occurred on the range was unknown. Cuvier's beaked whales have been involved in the majority of sonar-associated stranding events to date, thus there was reason to expect that they would not be prevalent on SCORE, where MFAS is routinely used year-round. The hope was that M3R would allow researchers to acoustically detect beaked whales on the range, if present, and that visual surveys would provide verification of species and numbers.

Contrary to expectations, a pair of Cuvier's beaked whales was encountered on SOAR with the assistance of acoustic localization in first verification test conducted there in August 2006. A pair of Baird's beaked whales was encountered in the next test, April 2007. The third test occurred in October 2007 during a period of unusually calm weather; 14 groups of Cuvier's beaked whales were encountered, suggesting that not only that they were present on the range, but that they were potentially present in much higher densities than had been reported for anywhere along the US West Coast previously (Falcone et al. 2009). Thus, the study of Cuvier's beaked whales at SOAR and adjacent basins has expanded in recent years, with 2-3 survey periods per year and enhanced data collection, including detailed surfacing behavior observations, photo-identification, genetic sampling, and deployment of satellite tags to collect data on both movement patterns and in some cases dive behavior.

Another key species found in and around SOAR is the fin whale (Balaeanoptera physalus). The fin whale population along the US West Coast was severely depleted by whaling through the late-1970s, and remains on the endangered species list today. Similar to Cuvier's beaked whales, fin whales are presently managed by the NMFS as a single stock from California to Washington State which was estimated at approximately 3,000 individuals in the most recent stock assessment report (Caretta et al. 2011), but there is insufficient data to describe both substructure and migratory patterns within the region. Line-transect surveys conducted from 1996 through 2008 were unable to detect a population trend throughout this time despite the ongoing protected status of the population (Barlow and Forney 2007; Forney 2007; Barlow 2010). Fin whales are the large whale species most frequently involved in vessel collisions throughout its range (Jensen and Silber, 2003), and this has included collisions with naval vessels at and near SOAR. While this species will sometimes utilize coastal habitat, the majority of fin whale sightings along the US West Coast occur in deep water far from shore. Both historical line-transect surveys and previous research by CRC have detected dense aggregations of fin whales in the outer waters of the Southern California Bight and on SOAR. This tendency to form dense, unpredictable aggregations in a high use training area, and the lack of data on population identity or seasonal use patterns underscores the importance of detecting any trends in formation of these aggregations, if they exist. As with beaked whales, this study has provided a dramatic increase in opportunities to collect detailed data from this offshore species not previously available, including photo-identification, genetics, and satellite telemetry.

While 2010 was the fifth survey season for visual verification tests at SOAR, and thus the majority of regularly encountered species can be reliably identified acoustically using M3R, the array underwent a substantial upgrade prior to the initial surveys of this study year. An additional 89 phones were placed within the existing range boundaries, with expanded bandwidth to ~50Hz to ~45kHz which would in theory allow for the detection of some large baleen whales with the M3R system for the first time.

METHODS

Surveys were conducted using a 6m rigid-hulled inflatable boat (RHIB), powered by two 75hp outboard motors and equipped with a raised bow pulpit to facilitate tag deployments. The vessel was launched from a shore base each morning and surveyed throughout daylight hours as conditions permitted. Effort was apportioned in two ways: dedicated surveys in conjunction with visual verification tests at SOAR, and opportunistic surveys of adjacent areas of SOCAL during periods of favorable weather, with an emphasis on the Santa Cruz Basin immediately to the north of the range. Beaked whales have been encountered in the Santa Cruz Basin without the assistance of acoustic detections in the past, and previously satellite tagged beaked whales from SOAR have also spent time there making it another point of interest within SOCAL. Surveys were generally attempted during months which had not been adequately surveyed in previous years with the goal of expanding seasonal coverage during the study. The vessel was staffed with two observers, both experienced in all aspects of data collection for this project including vessel operation in close proximity to species of interest, photography, remote biopsy sampling, and satellite tag deployment.

Surveys at SOAR were based at Wilson Cove on the northeast side of San Clemente Island. The RHIB was deployed at either Dana Point or Oceanside Harbor at the start of a survey period and remained moored in Wilson Cove for a period of 7-14 days, or until poor weather or conflicting range operations prevented further surveys at SOAR. Each morning the RHIB would transit around the north end of the island to the eastern boundary of the range. Staff from NUWC would monitor the hydrophones from the Range Operations Center on North Island in San Diego, and direct the RHIB via radio into areas where marine mammal vocalizations were detected. While the RHIB could be directed toward any vocalizations for visual verification, they were preferentially directed to those likely to be beaked whales when conditions were suitable for working with this species (typically winds at Beaufort 3 or less). Once the new hydrophones were integrated into M3R, the RHIB was preferentially directed to vocalizations likely to be large baleen whales in the absence of beaked whale vocalizations or when weather was likely to prevent visual detection of beaked whales.

Shorter opportunistic surveys were conducted at points throughout the year when weather forecasts were favorable and when the range was not available. In some cases opportunistic surveys were conducted during or immediately following dedicated surveys if range access prevented work at SOAR. During these surveys the RHIB was launched at harbors from San Diego to Santa Barbara, though most were conducted from Channel Islands Harbor in Oxnard, CA which provides the closest access to the Santa Cruz Basin. In calm conditions the RHIB would search broadly throughout the deep waters and shelf edges of the basin, stopping periodically to do 20-30 minute auditory scans when winds were below Beaufort 2 (beaked whales can often be detected by the sound of their respirations at ranges greater than they can be detected visually in very calm conditions). Surveys were also occasionally conducted in nearshore waters in response to reports of concentrations of fin whales. Finally, several satellite tags purchased under this grant were deployed opportunistically during a concurrent marine mammal study in the region in which staff from this project participated (see Southall et al. 2011).

Each time a group of cetaceans was encountered, the species, time, latitude, longitude, group size and composition, and overall behavioral state was recorded. For encounters with beaked whales, detailed records of surfacing patterns were also collected for as long as contact with the group was maintained. Photographs were taken for species verification where questionable, and for individual identification for species where this methodology is being employed during this study or by collaborators (beaked, fin, blue, humpback, and killer whales; bottlenose and Risso's dolphins). Remote tissue biopsies were collected from species of interest both in this study (beaked and fin whales), and also for collaborators at the Southwest Fisheries Science Center for ongoing assessments of offshore populations in the Bight (including Pacific white-sided, northern right whale, Risso's, and bottlenose dolphins). Finally, satellite tags were deployed predominantly on beaked whales, fin whales, and Risso's dolphins.

Tags deployed were of the Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) design (Andrews et al. 2009, Schorr et al. 2009, Baird et al. 2010). Two types were used: a location-only SPOT5 or a location and depth-reporting Mk10-A SPLASH tag (Wildlife Computers, Inc., Redmond, WA). Two attachment darts on the bottom of the tag penetrated 4.5cm (small species, e.g. Risso's dolphins) or 6.5cm (large species, e.g. beaked whales, fin whales) into the dorsal fin. Tags were programmed to transmit for variable periods during the day, corresponding to periods with best satellite overpasses. Dive reporting tags were programmed to best capture the behavior of the intended target species. Decisions on which tag type to use were based on average tag longevity by species, surfacing characteristics, and data gaps.

Data obtained from the Argos system was processed with the Douglas Argos-Filter v.7.08 (available at Alaska.usgs.gov/science/biology/spatial/douglas.html) using two independent methods: distance between consecutive locations, and rate and bearings among consecutive movement vectors. Depth and distance from shore for all locations which passed the Douglas Argos-filter were determined in ArcGIS v. 9.2 (ESRI, Redlands, California). Dive data was decoded using Wildlife Computers-Data Analysis Program (WC-DAP), version 3.0 (Build 30).

At the completion of each survey, sighting data were compiled in a MS Access data structure designed for maintaining data associated with this project. Photographs were reviewed, with those from fin whales and beaked whales processed to identify the best available identification photos of each individual within each sighting. These photographic records were then sent to species-specific MS Access digital cataloging systems also designed and maintained by CRC, where they were reconciled across sightings during the study and compared to photographs of individuals from previous years. Cuvier's beaked whales identified during 2010-2011 were compared against a historical catalog of approximately 90 individuals, the majority of which were photographed at SOAR from 2006-2009 with a small number of extra-regional contributions from northern Mexico and central California. Fin whales identified in 2010-2011 were combined with fin whales identified in 2009 and compared against a fin whale historical catalog that was just completed under a separate contract in January 2011. This catalog contained approximately 250 individual whales identified at points from Northern Mexico through the Gulf of Alaska from 1988-2008, though the majority of individuals in the catalog were photographed in the Southern California Bight from 2003-2008.

RESULTS AND DISCUSSION

Effort and Sightings

A total of 33 surveys were conducted during the study period, with just over half of these days spent in dedicated surveys based at SCORE and emphasizing SOAR (**Table 1, Figure 1**). Surveys were conducted at SOAR during January and May 2011, representing the first time sighting data was collected during these months since small-boat surveys at SCORE began in 2006.

Twelve cetacean species were sighted during surveys (**Table 2, Figures 2A-2C**). Surveys in January detected several new trends that had not been observed in other seasons. In general, both the diversity and density of species in the study was much lower than has been observed in summer and fall. Only three different species were sighted during surveys at SOAR from 5-7 January 2011: gray whales, Dall's porpoise, and Cuvier's beaked whales. All gray whales observed during this period were traveling south along a fairly narrow path near the center of SOAR (**Figure 2B**). Dall's porpoise are infrequently sighted in all other months of the year, but 9 groups containing up to 25 individuals were observed during surveys in January. While both these patterns have been previously described for the species in question (e.g. Forney and Barlow, 1998 for Dall's porpoise; Sumich and Show, 2011 for gray whales) this confirms their increased seasonal abundance on the range and the continued use of the San Clemente Island migratory corridor by southbound gray whales- though most gray whales observed during this study appeared further west of the island than was observed by Sumich and Show (2011) in the early 1990s. January surveys also provide evidence that Cuvier's beaked whales are present on the range year-round.

Table 1. Summary of survey effort by day June 2010-June 2011 during N45-supported studies in the Southern California Bight. (Note that "Total" for Species is the number of unique species identified throughout the study year, and thus not a summation across days).

Date	Effort (Hours)	Distance (km)	Survey Area	Sightings	Species
15-Jun-10	4.6	102.8	Oceanside-San Clemente Island	4	1
16-Jun-10	5.8	112.3	SCORE	2	1
17-Jun-10	10.1	156.9	SCORE	3	3
18-Jun-10	6.3	162.9	San Clemente Island-Oceanside	0	0
20-Jun-10	5.9	110.4	San Diego	8	5
21-Jun-10	8.8	188.3	SCORE	8	5
22-Jun-10	10.9	186.7	SCORE	2	2
23-Jun-10	7.5	98.1	SCORE	3	3
24-Jun-10	8.7	122.1	SCORE	6	5
25-Jun-10	3.4	49.8	SCORE	2	1
27-Jun-10	12.0	181.9	SCORE	8	5
28-Jun-10	12.9	147.6	SCORE	8	3
29-Jun-10	12.9	186.7	SCORE	8	4
30-Jun-10	2.3	82.3	San Clemente Island-Dana Point	0	0
06-Jul-10	6.6	183.5	Santa Cruz Basin	3	2
04-Jan-11	5.6	114.9	Dana Point-San Clemente Island	5	4
05-Jan-11	10.0	135.4	SCORE	2	2
06-Jan-11	10.4	157.6	SCORE	7	2
07-Jan-11	10.1	154.7	SCORE	7	3
08-Jan-11	3.6	86.1	San Clemente Island-Dana Point	2	2
11-Jan-11	8.7	183.5	Santa Cruz Basin	6	3
30-Apr-11	3.1	81.6	Dana Point-San Clemente Island	0	0
01-May-11	11.5	150.1	SCORE	6	5
02-May-11	13.4	181.9	SCORE	5	4
04-May-11	9.5	134.5	SCORE	3	1
05-May-11	11.9	200.9	SCORE	8	6
06-May-11	10.2	162.9	SCORE	3	2
07-May-11	2.6	82.3	San Clemente Island-Dana Point	1	1
18-Jun-11	7.5	111.2	San Diego South	7	3
20-Jun-11	10.3	205.7	Santa Cruz Basin	4	2
21-Jun-11	10.7	218.3	Santa Cruz Basin	6	3
22-Jun-11	13.2	231.0	Santa Barbara Channel	23	6
23-Jun-11	4.5	121.0	Dana Point-Long Beach	3	3
33	276	4786	TOTAL	163	12

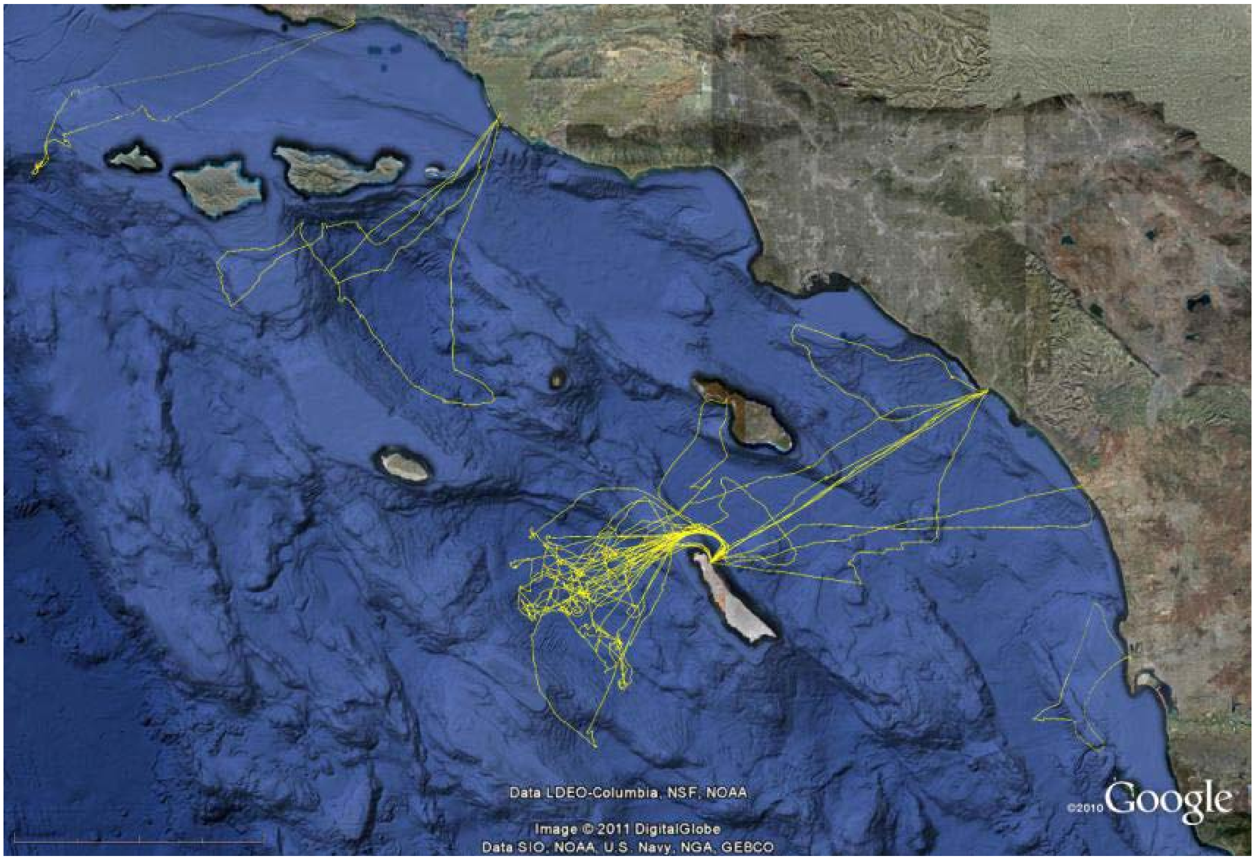

Figure 1. Vessel track lines from surveys conducted June 2010- June 2011.

Table 2. Summary of cetacean sightings by species, including photo-ID, tissue samples collected, and satellite tags deployed from June 2010 through June 2011.

Group	Species	Groups Sighted	Est Individuals Sighted	Avg Group Size	Est Photo IDs	Tissue Samples	Satellite Tags
Baleen Whales	Blue Whale (*Balaenoptera musculus*)	11	39	4	27		
	Fin Whale (*Balaenoptera physalus*)	23	45	2	33	5	7
	Gray Whale (*Eschrichtius robustus*)	9	22	2	4		
	Humpback Whale (*Megaptera novaeangliae*)	5	54	11	29		
	Minke Whale (*Balaenoptera acutorostrata*)	3	3	1	0		
Beaked Whales	Cuvier's Beaked Whale (*Ziphius cavirostris*)	14	34	2	32	1	5
Delphinids	Bottlenose Dolphin (*Tursiops truncatus*)	15	272	18	12		
	Common Dolphin Species (*Delphinus spp*)	9	252	28			
	Long-beaked Common Dolphin (*D. capensis*)	8	1294	162			
	Short-beaked Common Dolphin (*D. delphis*)	14	1332	95			
	Northern Right Whale Dolphin (*Lissodelphis borealis*)	6	677	113		6	
	Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)	6	111	19			
	Risso's Dolphin (*Grampus griseus*)	27	394	15	144	1	4
Porpoises	Dall's Porpoise (*Phocoenoides dalli*)	14	96	7			

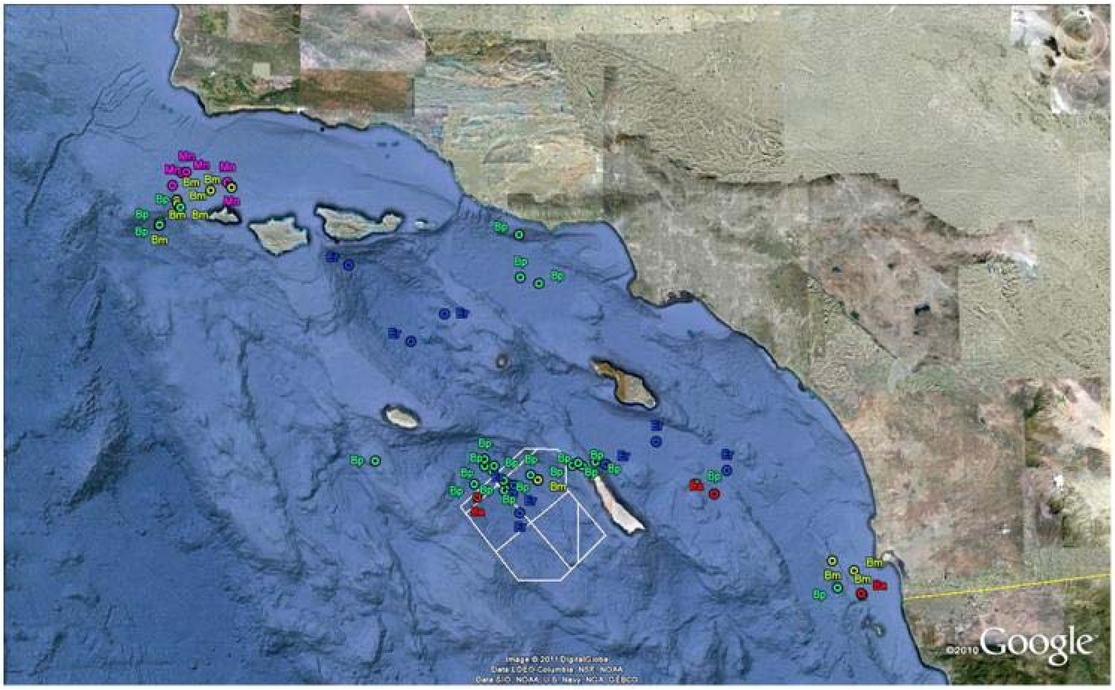

Figure 2A. Sightings of baleen whales June 2010-June 2011. Of note were frequent sightings of southbound gray whales transiting through the center of SOAR in January.

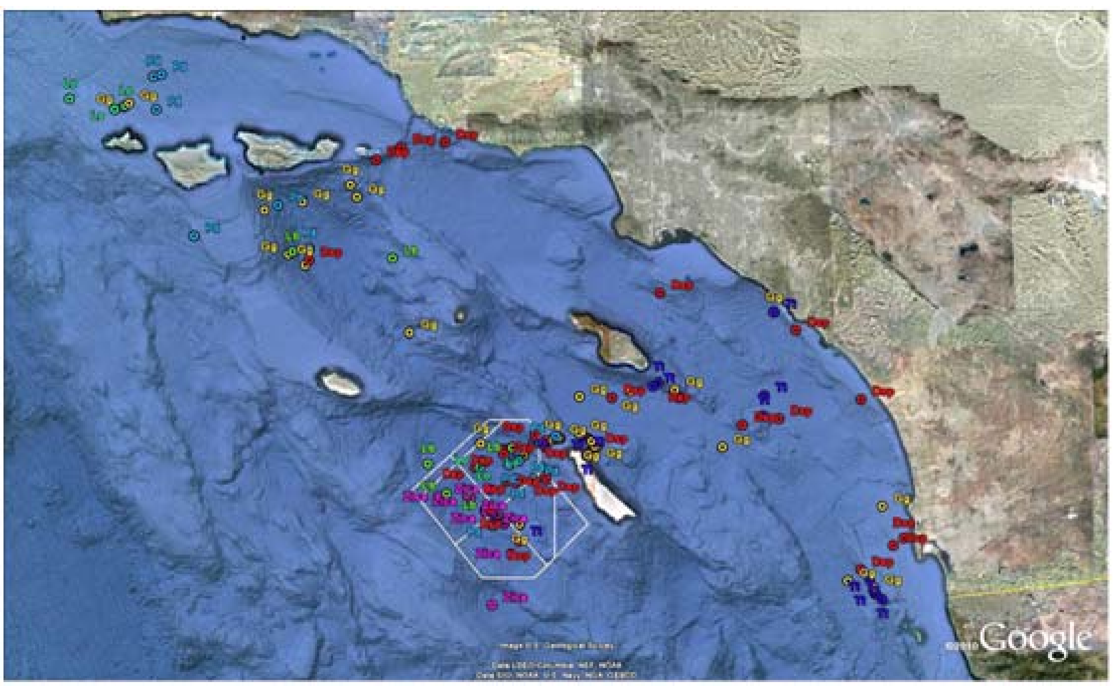

Figure 2B. Sightings of odontocetes June 2010-June 2011. In general the distribution was similar to previous years, though both Dall's porpoise and northern right whale dolphins were encountered more frequently in surveys in winter and spring than in other times of year.

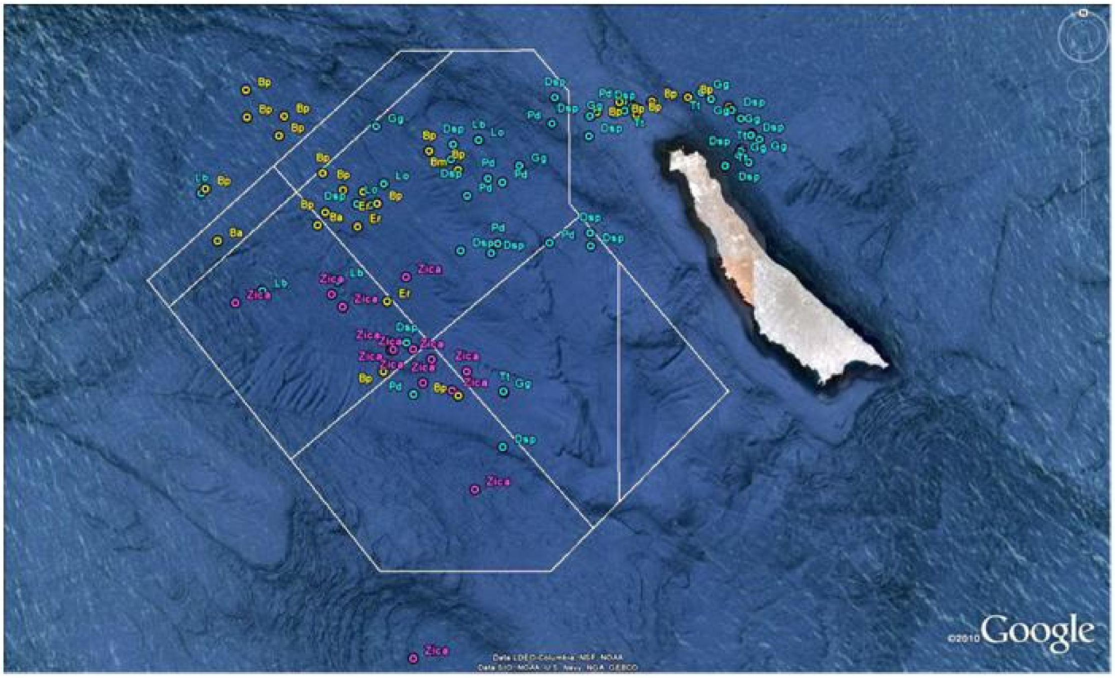

Figure 2C. A detail of cetacean sightings in and around SOAR June 2010- June 2011, with baleen whale species in yellow, small odontocetes in blue, and Cuvier's beaked whales in pink.

Photo-Identification

Individual identification photographs were collected from seven species during surveys. Photographs from five of these species were contributed to other ongoing photographic studies managed by CRC or SIO/SWFSC; photos of Cuvier's beaked whales and fin whales were processed as part of this project.

Of the 34 individual Cuvier's beaked whales sighted during the study, 32 were photographed for identification purposes. These photos were reconciled internally resulting in 29 suitable quality identifications of 25 unique individuals. Two of these individuals were sighted on more than one day in the study period, and 8 (32%) had been photographed at SOAR in previous years. These identifications bring the total number of known individuals in the CRC catalog to 100, of which 79 were photographed on SOAR. To date 11 of these 79 whales have been sighted in more than one year for an overall inter-annual resighting rate of 14%. No identified whales have been observed in areas outside the San Nicolas Basin, though the sample of whales from other areas is quite small. Preliminary comparisons of photographs from the initial years of this study hinted that the San Nicolas Basin, and hence the SOAR range, might be home to a localized population of Cuvier's beaked whales (Falcone *et al*. 2009). This recent increase in matches to previous years along with the results of satellite telemetry (detailed in the next section of this report) both underscore the likelihood that a resident population exists with small core use area. With an additional season of photo-ID data collection the sample should be suitable for estimating population size with mark-recapture statistics.

Of 45 fin whales sighted during this study period, 33 were photographed for identification purposes. Because the fin whale historical catalog through 2008 was only finalized in January 2011, the internal reconciliation and historical comparison of fin whales from 2009-2010 is still underway at the time of this report, with an anticipated completion in August 2011. All fin whale identifications from this and other fieldwork by CRC in 2011 will be processed beginning in fall of 2011 with results available in late spring 2012. Preliminary results suggest 16 unique individuals were photographed during this study in 2010.

None of these whales were sighted on more than one day, and none appear to have been sighted in previous years. A technical report summarizing fin whale photo-identification along the US West Coast through 2008, which contains a large proportion of data from previous study years in the SCORE region, is available at

http://www.cascadiaresearch.org/Falconeetal2011BPIDcontractreport-Final.pdf.

Satellite Telemetry

Twenty satellite tags were deployed in on seven species including one probable Sei-fin hybrid (**Table 3**). Eleven tags provided location data only for periods up to 124 days. Nine tags provided dive behavior records in addition to locations; these provided up to 90 days of data.

Cuvier's beaked whales

Five depth-reporting LIMPET tags were deployed, one each on unique individuals from different groups of Cuvier's beaked whales. Grand mean distance to tagging location for all individuals across all days transmitting was only 80 Km, with a maximum distance from tagging location of 452 Km (**Table4**). While 3 of the 5 individuals showed movements away from the San Nicolas Basin, two of the three returned (**Figure 3**). When combined with movement data collected from two previously tagged individuals, tagged animals have been documented on SOAR in all months except May to date. These movement patterns suggest a high degree of residency to the Southern California Bight, and to the SOAR range in particular, consistent with photo-ID results. While in the San Nicolas Basin, which includes the SOAR range, individuals preferentially used the western and northern edges of the basin. The average water depth utilized was 1,330m and average minimum-straight line movements between locations suggested movement rates of 1.8 km/hr (**Table 4**). Over 3,800 hours of dive behavior was collected, representing the longest and most complete dataset on Cuvier's movement and dive behavior to date. Analysis is still underway, but preliminary results indicate all individuals dove to greater than 1,500m and two of the individuals had dives to depths greater than 2,000m. Four individuals had dive durations greater than 90 minutes, with one dive exceeding two hours (Schorr et al. 2011). All Cuvier's tags were deployed prior to scheduled MFAS training exercises at SOAR, and analysis of overlapping periods of sonar use concurrent with animal location and dive behavior is currently being undertaken in collaboration with NUWC (D. Moretti), along with a more general in-depth analysis of diving behavior patterns from this unique and comprehensive dataset (**Figure 4**).

*Table 3. Summary of tag deployments made in year 1. L = location only, L/D = location and depth-reporting LIMPET tag. * denotes tags from this contract which were deployed during field efforts funded by other sources.*

Species	TagID	Deploy Date	Transmission Duration (days)	Tag Type
Baird's beaked*	Bba Tag 001	07-Aug-10	32	L
Sei/fin (prob hybrid)*	Bbo/Bp Tag 001	26-Aug-10	21	L
Fin whale	Bp Tag 021	28-Jun-10	124	L
Fin whale	Bp Tag 022	28-Jun-10	27	L
Fin whale	Bp Tag 026	04-May-11	4	L/D
Fin whale	Bp Tag 027	04-May-11	1	L/D
Fin whale	Bp Tag 028	06-May-11	25	L/D
Fin whale	Bp Tag 029	22-Jun-11	Still Trans	L
Fin whale	Bp Tag 030	22-Jun-11	Still Trans	L
Risso's dolphin	Gg Tag 003	24-Jun-10	20	L
Risso's dolphin	Gg Tag 004	24-Jun-10	12	L
Risso's dolphin	Gg Tag 005	08-Jan-11	7	L
Risso's Dolphin	Gg Tag 006	18-Jun-11	Still Trans	L/D
Killer Whale*	Oo Tag 019	07-Sep-10	9	L
Sperm whale*	Pm Tag 014	16-Aug-10	92	L
Cuvier's beaked	Zc Tag 010	29-Jun-10	54	L/D
Cuvier's beaked	Zc Tag 011	29-Jun-10	90	L/D
Cuvier's beaked	Zc Tag 014	06-Jan-11	23	L/D
Cuvier's beaked	Zc Tag 015	06-Jan-11	71	L/D
Cuvier's beaked	Zc Tag 016	06-Jan-11	89	L/D

Table 4. Details of five depth-reporting LIMPET tags deployed on Cuvier's beaked whales.

TAGID	Transm. Duration (days)	Cumulative Straight-line Distance Traveled (Km)	Avg Dist To Deploy (Km)	Max Dist to Deploy (Km)	Avg min rate of straightline movement (Km/Hr)	Avg Dist to Shore (Km)	Avg Water Depth (m)
Zc010	54	1940.2	65.7	265.5	1.7	29.8	-1226.6
Zc011	90	2334.1	153.9	289.5	1.8	48.3	-1256.6
Zc014	23	785.5	33.8	94.4	1.8	30.5	-1181.8
Zc015	71	2731.1	122.9	452.3	2	64.3	-1723.6
Zc016	89	1826	26.1	103.2	1.6	40.8	-1263.1

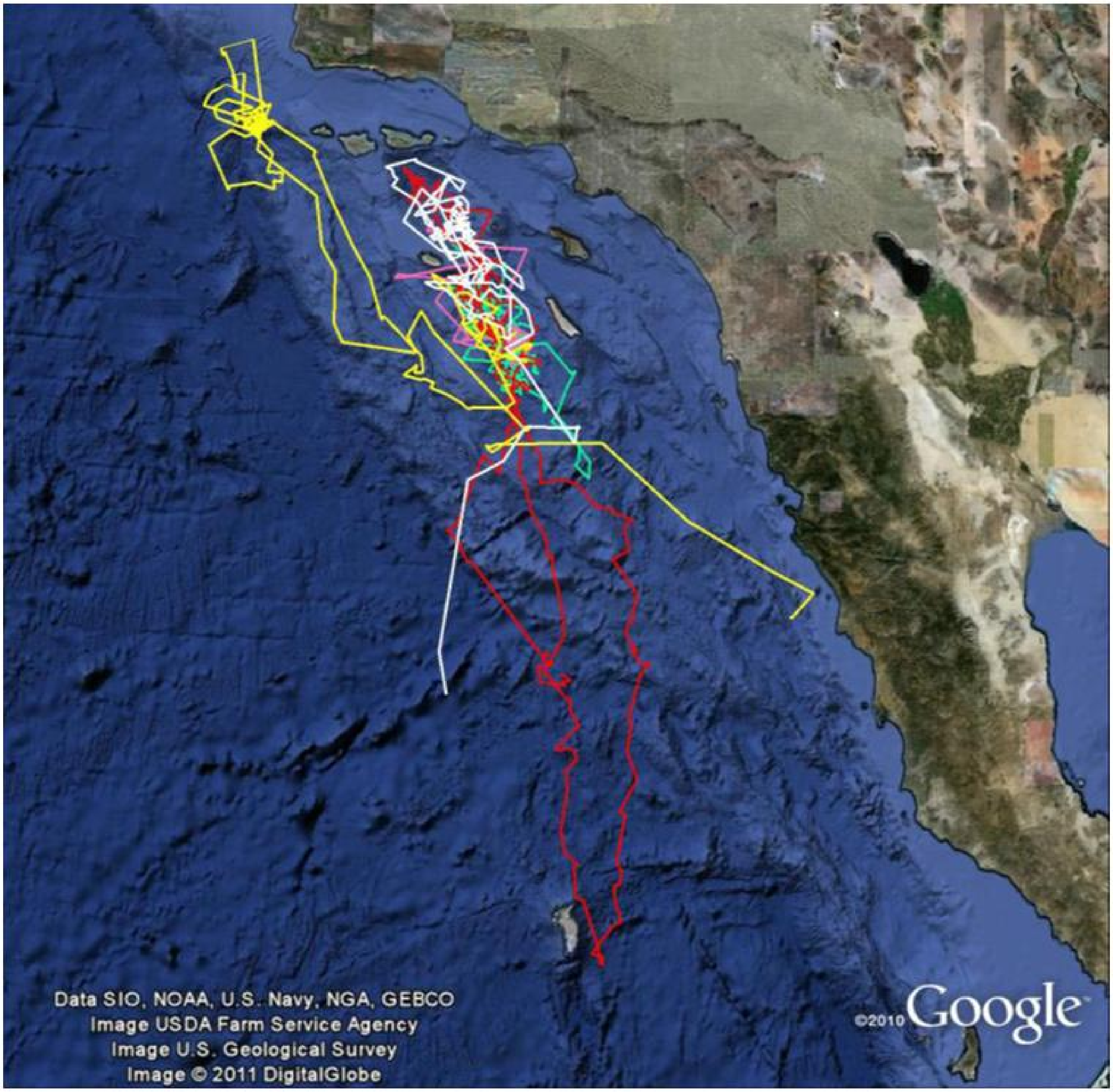

Figure 3. Movements of five Cuvier's beaked whales.

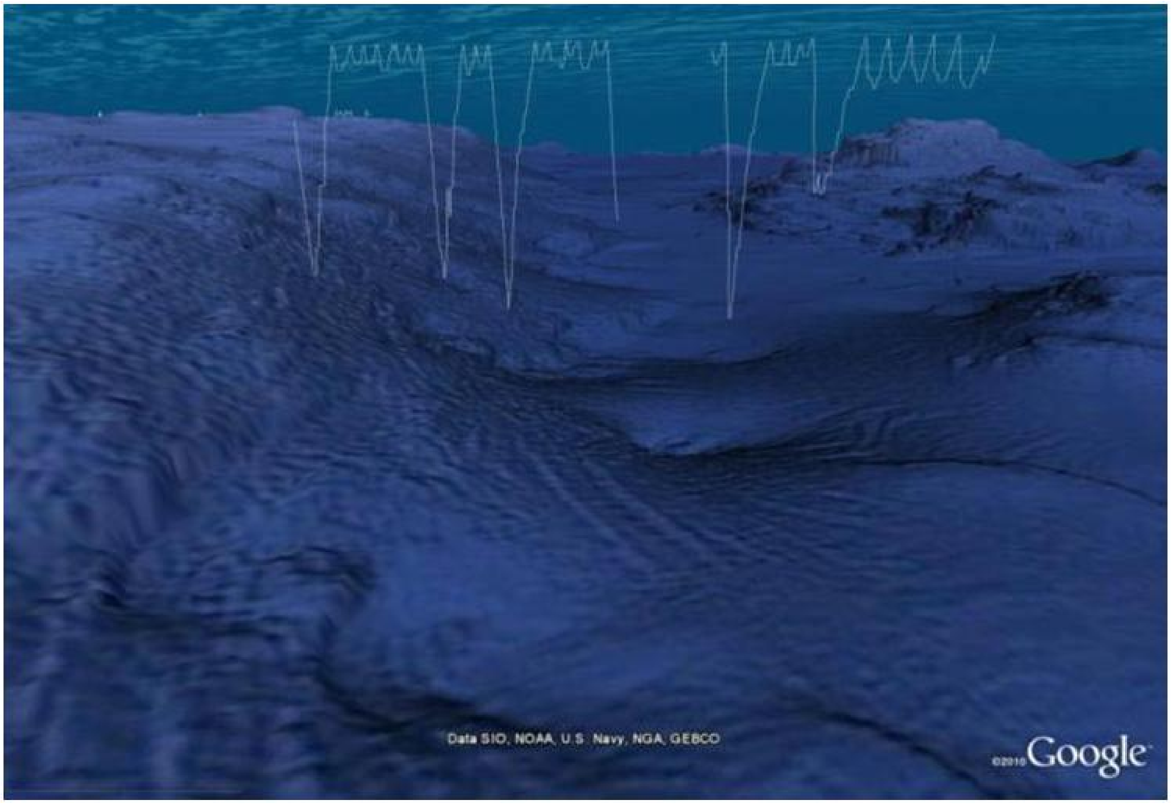

Figure 4. A combination of interpolated tracks from Argos location data and concurrent dive behavior, allows for a rough assessment of dive behavior in relation to bathymetric features. Here, a portion of Zc Tag 011 dive log is displayed with a 3D view of local bathymetry.

Fin Whales

Seven satellite tags were deployed on fin whales on four different days. One pair of individuals was tagged 180km northwest of SOAR, west of San Miguel Island (both individuals still transmitting at the time of this report, and therefore not included in analysis), while the remaining tags were all deployed in or near the San Nicolas Basin. The average distance to deployment for tags which transmitted for more than seven days was 178 km and maximum distance to deployment for all tags was 320 km (Bp Tag 021, with transmission duration of 124 days). Two of the whales made forays out of the Southern California Bight, and north of Point Conception, with Bp Tag 021 spending two months off of Monterey Bay before returning south. While there was some limited use of nearshore waters among the Channel Islands, including within the 3-mile vessel exclusion area around SWAT 1 and 2 on the north end of San Clemente Island, individuals largely spent time in deep water, and further offshore (**Figure 5**). Three of the seven tags were dive-depth reporting LIMPET tags, but only one of these transmitted for longer than 4 days (Bp Tag 028, 25 days). Grand mean average rate of straight line movement between subsequent locations was 2.2 Km/hr, only slightly higher than the 1.8 Km/hr for the Cuvier's beaked whales. Data from these tags will be compiled with other satellite tag data from fin whales along the US West Coast (e.g. Schorr et al. 2010), and will be combined with photo-ID and genetics to better understand the fin whale population that utilizes habitat within the Bight for future management.

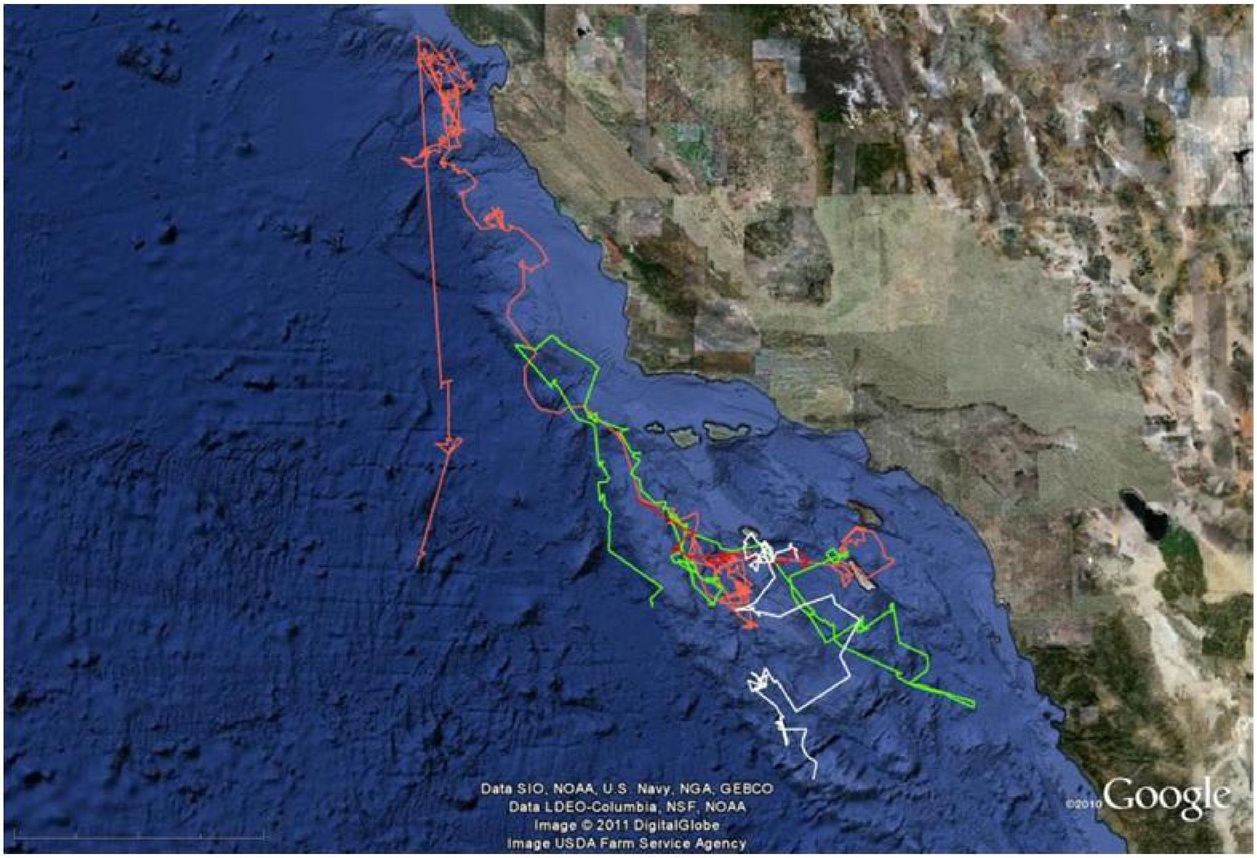

Figure 5. Movement of fin whales tagged during the contract period in the San Nicholas Basin.

Risso's dolphins

Four LIMPET tags were deployed on Risso's dolphins, three location-only and one dive-depth reporting (still transmitting at the time of this report). The median transmission duration was 12 days (range = 7 – 20). The grand mean distance to tagging location was 64 km, with a maximum distance from tagging location of 155 km (**Table 5**). While one individual spent time in the nearshore waters of SHOBA on the south end of San Clemente Island (similar to one individual tagged in July of 2009), the majority of time was spent in the deep water basins, away from the islands and the mainland coast. Grand mean bottom depth at locations was 947.4m and distance to shore was 25.6 km (**Figure 6**). Excluding the one tag still transmitting, all tagged Risso's from this and previous study years have moved between basins, suggesting individuals are not resident to specific islands or basins, though they may be resident within the Bight overall (**Figure 6**). Longer tag deployments will be required to better resolve population structure of this species.

Table 5. Information on four Risso's dolphins tagged between June 2010 and January 2011.

Tag ID	Transm. Duration (days)	Cumulative straight-line Distance Traveled (Km)	Avg Dist to Deploy (Km)	Max Dist to Deploy (Km)	Avg min rate of straightline movement (Km/Hr)	Avg Dist to Shore (Km)	Avg Water Depth (m)
Gg Tag 003	20	1427.1	68.6	154.7	2.6	27.3	-967.7
Gg Tag 004	12	841.3	87.4	148.7	3.4	26.5	-974.4
Gg Tag 005	7	504.2	36.1	66.3	3.1	23	-900.1
Gg Tag 006				*still Transmitting*			

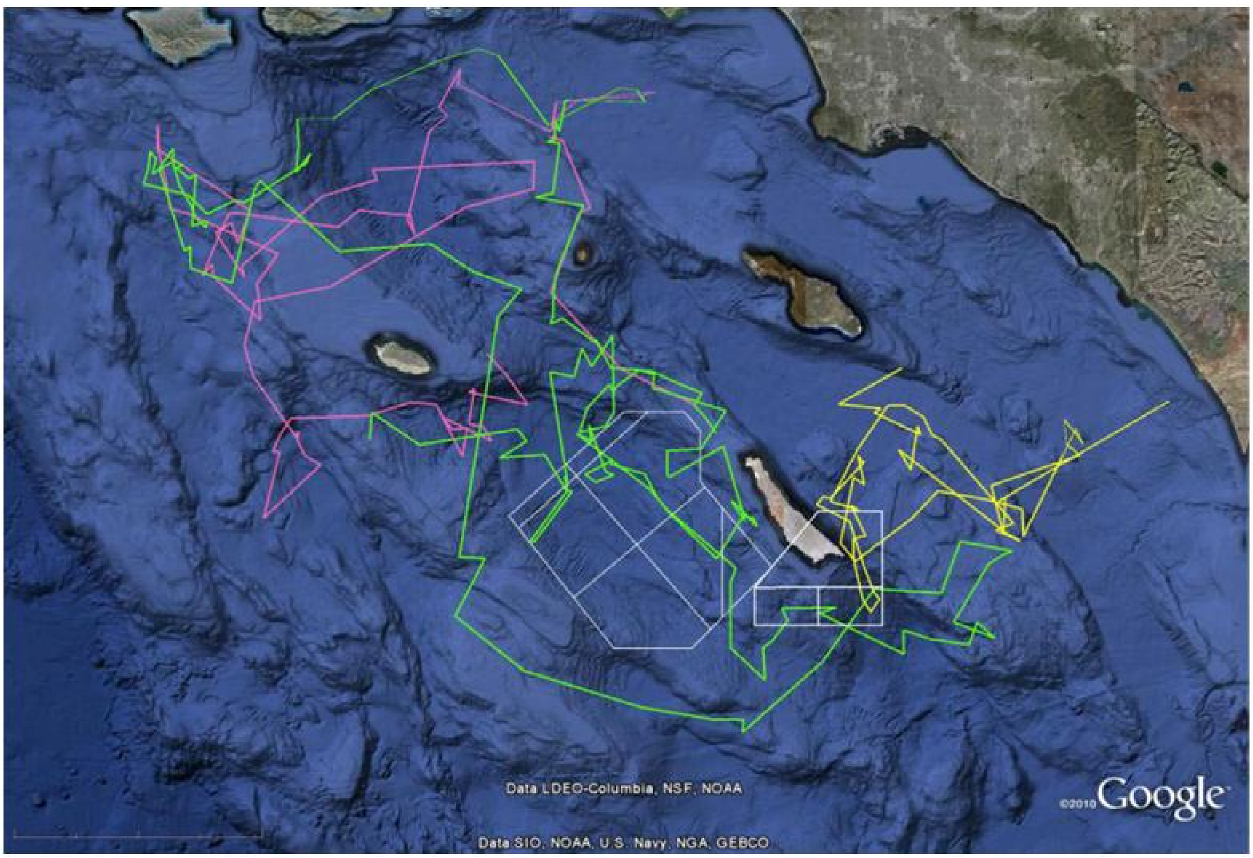

Figure 6. Map showing movements of three tagged Risso's Dolphins, June 2010 thru May 2011. Note the SOAR and SHOBA ranges outlined in white.

CONCLUDING REMARKS

The preliminary results gathered in the first year of effort under this grant continue to provide new insights into the occurrence, distribution and habitat use of cetaceans in the Southern California Bight. The long term movement and dive behavior records from Cuvier's beaked whales, and on an active navy training range, is an especially valuable dataset that may provide new insights into interactions between this population and Navy exercises. We hope that the continued collection of photographic, genetic, and satellite data from fin whales and beaked whales in subsequent years of this will substantially improve the management of these two species. We also hope that these results will provide the necessary behavioral framework in which to evaluate the results of experimental sonar exposure studies, underway concurrently in the region.

ACKNOWLEDGEMENTS

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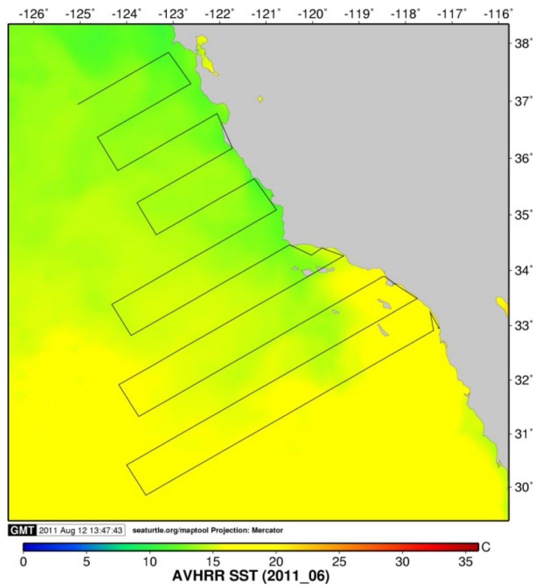
CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATION (CALCOFI) CRUISES: 2010-2011



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ABSTRACT

Spatial and temporal distribution patterns, density and abundance of cetaceans in the southern California Bight were assessed through visual and acoustic surveys during four California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from August 2010 – April 2011. Visual monitoring incorporated standard line-transect protocol during all daylight transits while acoustic monitoring employed a towed hydrophone array during transits and sonobuoys at oceanographic sampling stations. Visual effort included 455 observation hours covering 3,800 kilometers yielding 268 sightings of 15 cetacean species. Fin whales were the most frequently sighted baleen whale species, followed by blue, gray, and humpback whales. Common dolphins were the most frequently sighted odontocete species, followed by bottlenose dolphin, Dall's porpoise, Pacific white-sided dolphin, Risso's dolphin, and sperm whale. Seasonal variations in encounter rates and distributions were evident for some species. Grey whales and Dall's porpoise were sighted primarily in fall and winter, whereas blue and fin whales were visually detected in spring and summer. Pacific white-sided dolphins were observed in all seasons except summer. Sperm whales were only sighted during fall and winter cruises. There was no apparent seasonal pattern to sightings of bottlenose, common and Risso's dolphins, though Risso's dolphins were not detected during the fall survey. Spatial variations in visual detections as a function of species were also evident. Bottlenose, Risso's and long-beaked common dolphin as well as humpback and gray whale detections were concentrated in coastal and shelf waters, whereas sperm whale detections occurred exclusively in pelagic waters. Short-beaked common dolphin, Pacific white-sided dolphin, Dall's porpoise, fin, and blue whales had a broader distribution with encounters occurring in coastal, shelf and pelagic waters. Each species showed distinct spatial and temporal distribution patterns across the study area; indicative of species-specific habitat preferences within the California Current ecosystem. Current research is investigating the association between cetacean distribution with biological and physical oceanographic variables measured during CalCOFI surveys. Density and abundance estimates of cetaceans encountered in the study area are currently the focus of an extensive line-transect analysis and modeling effort. Modeling of cetacean habitat preferences in conjunction with density and abundance estimates, will provide data needed to evaluate potential impacts from anthropogenic activities and ultimately for the development of comprehensive management protocols.

INTRODUCTION

Cetacean surveys have been integrated into California Cooperative Oceanic Fisheries Investigation (CalCOFI) quarterly cruises off southern California since 2004. CalCOFI cruises have been conducted consistently on the same transect lines over the past 60 years and provide one of the longest and most extensive time series of physical and biological oceanographic data in existence. Cetacean monitoring by Scripps Institution of Oceanography incorporates both visual and acoustic methods to assess cetacean populations occurring in the California current ecosystem. The objectives of the cetacean monitoring program are to determine the temporal and spatial patterns of cetacean distribution, to compare visual and acoustic survey methods and results, to quantify differences in vocalizations between cetacean species, and to make seasonal estimates of cetacean density and abundance within the study area. The greatest strength of CalCOFI cetacean surveys is the broad seasonal and geographic coverage within SOCAL. Sample sizes are comparable or greater than the total number of SWFSC sightings from the region. The weakness of CalCOFI cetacean surveys are that, due to time constraints, the vessel cannot alter course during the survey to better estimate group sizes and/or species identification. A comparison of visual and acoustic methods has demonstrated that most species are detected by both methods. CalCOFI cetacean surveys are planned to continue for at least the next three years. To date, estimates of cetacean density and abundance have been limited to blue, fin, and humpback whales; however, extensive line-transect analysis encompassing all commonly sighted species is currently underway. Recent analysis of baleen whale density relative to habitat type and productivity levels has proven insightful for expanding the scope and complexity of habitat modeling efforts.

METHODS

Visual Monitoring

Visual monitoring for cetaceans on four quarterly CalCOFI cruises during 2010-2011 utilized standard line-transect marine mammal survey protocol. Visual observers searched during daylight hours under acceptable weather conditions during all transits between CalCOFI stations (Beaufort sea state 0-5 and visibility greater than 1 nm). Data on time, position, ship's heading/speed, and environmental conditions were recorded at regular intervals or when conditions changed. Information on all cetacean sightings was logged systematically, including distance and bearing from the ship, species identification, group composition, estimated group size and behavior. During all surveys, 18x power binoculars were used to improve species identification after an initial sighting using 7x binoculars. See Appendix I for a comprehensive list of species included in this report along with their abbreviation codes.

Acoustic Monitoring

Acoustic monitoring for cetaceans during line-transect surveys was conducted using a 6-element 300 m towed hydrophone array. Each pre-amplified element was band-pass filtered from 3 kHz to 200 kHz to decrease flow noise at low frequencies and to protect from signal aliasing at high frequencies. The multi-channel array data were sampled using both a MOTU 896 at 192 kHz and a National Instruments USB 6152 at 500 kHz to allow for a broad range of frequencies to be recorded. An acoustic technician monitored the incoming signals from the towed array using both a real-time scrolling spectrogram and headphones. In addition, acoustic monitoring while on CalCOFI stations was conducted with both broadband passive SSQ-57B omni-directional and SSQ-53F DIFAR sonobuoys. Sonobuoys were deployed 1 nm before each daylight station to a depth of 30 m and recorded for 2-3 hours while oceanographic sampling was underway. An acoustic technician monitored the sonobuoy signals for cetacean calls using a scrolling spectrogram display. Mysticete calls, sperm whale clicks as well as low frequency dolphin calls, including whistles, buzzes and the lower frequency components of clicks were recorded with this system.

Density and Abundance Analysis

Density and abundance analysis for nine cetacean species common to the study area of approximately 180,930 km^2 are being conducted with Distance 6.0 software. Visual data collected during twenty-eight cruises from July 2004 through April 2011 is being analyzed for both seasonal and annual patterns in density and abundance. Analytic, model-based and probability density designs have been incorporated into the current analysis to assess what approaches are best suited for the CalCOFI dataset. Preliminary analysis support the application of a model-based design which will allow us to estimate how abundance varies throughout a study area by modeling encounter rates along the line as a function of spatial covariates. Potential covariates include oceanographic variables, geographic coordinates, distance from land, and depth. Model-based approaches have become increasingly popular for analyzing distance sampling data, as they help us to understand what factors influence animal distributions, and they can be used even when transect lines are not randomly placed.

Acoustic Data Analysis

Acoustic data collected from the towed acoustic array was analyzed in real-time for the presence of calls from all odontocete cetaceans. Sonobuoys deployed on CalCOFI stations were analyzed in real-time for presence of blue, fin and humpback whale vocalizations as well as odontocete calls. Field-based event detections from the towed array and sonobuoys are further examined post-cruise to confirm initial signal classification and to better characterize call characteristics. The structural elements of cetacean calls collected on CalCOFI cruises are currently being measured and applied to the development of a suite of detection and classification algorithms. Baleen whale calls are measured along several parameters including duration, frequency structure, and inter-call interval. Odontocete echolocation clicks are assessed through the calculation of several variables including duration, inter-click interval, peak frequency points, -3dB bandwidth, -10 dB bandwidth and center frequency. Delphinid whistle structure analysis entails the extraction of eight specific variables from each whistle contour: begin frequency, end frequency, minimum frequency, maximum frequency, frequency range, mean frequency, duration, and number of inflection points. Call variables are subsequently applied to multivariate statistical analysis to examine the within species/population and between species/population variability inherent in the data.

RESULTS AND DISCUSSION

Line-transect visual surveys

Four surveys covering 3,813 nautical miles of track-line with 455 hours of effort were conducted from 1 August 2010 to 31 July 2011. Cetacean surveys conducted in August 2010, November 2010 and April 2011 utilized the standard CalCOFI station pattern; efforts in January 2011 also surveyed the northern transects. Survey tracks representing visual and acoustic array effort for each of the four cruises are presented in Figure 1. Summary data on effort and sightings from the four CalCOFI surveys conducted from August 2010 – April 2011 are provided in Tables 1 and 2. Plots of all visual detections across the four cruises classified to species are provided in Figure 2.

Cetacean sightings across the four CalCOFI cruises included 10 odontocete and five mysticete species encompassing a total of 268 encounters (Table 2). Encounter rates of cetaceans in the study area varied by species. Fin whales were the most frequently sighted baleen whale species, followed by blue, gray, and humpback whales. Common dolphin were the most frequently encountered odontocete, followed by bottlenose dolphin, Dall's porpoise, Pacific white-sided dolphin, Risso's dolphin, and sperm whale. Killer whales and northern right-whale dolphins and were the least frequently encountered cetaceans with only one sighting per species during the four cruises (Table 2).

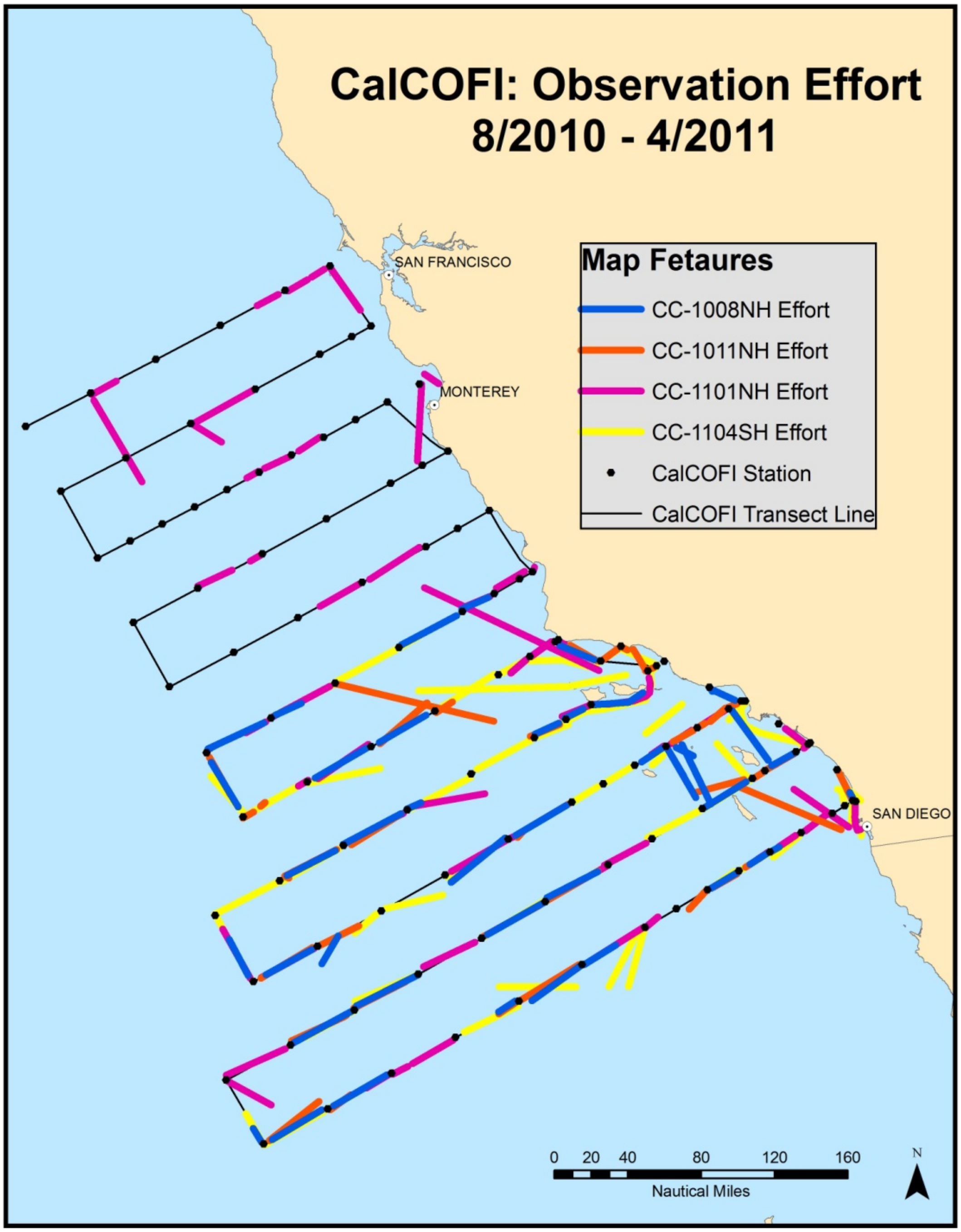

Figure 1. Marine mammal visual/acoustic survey effort by season from four CalCOFI cruises between August 2010 and April 2011.

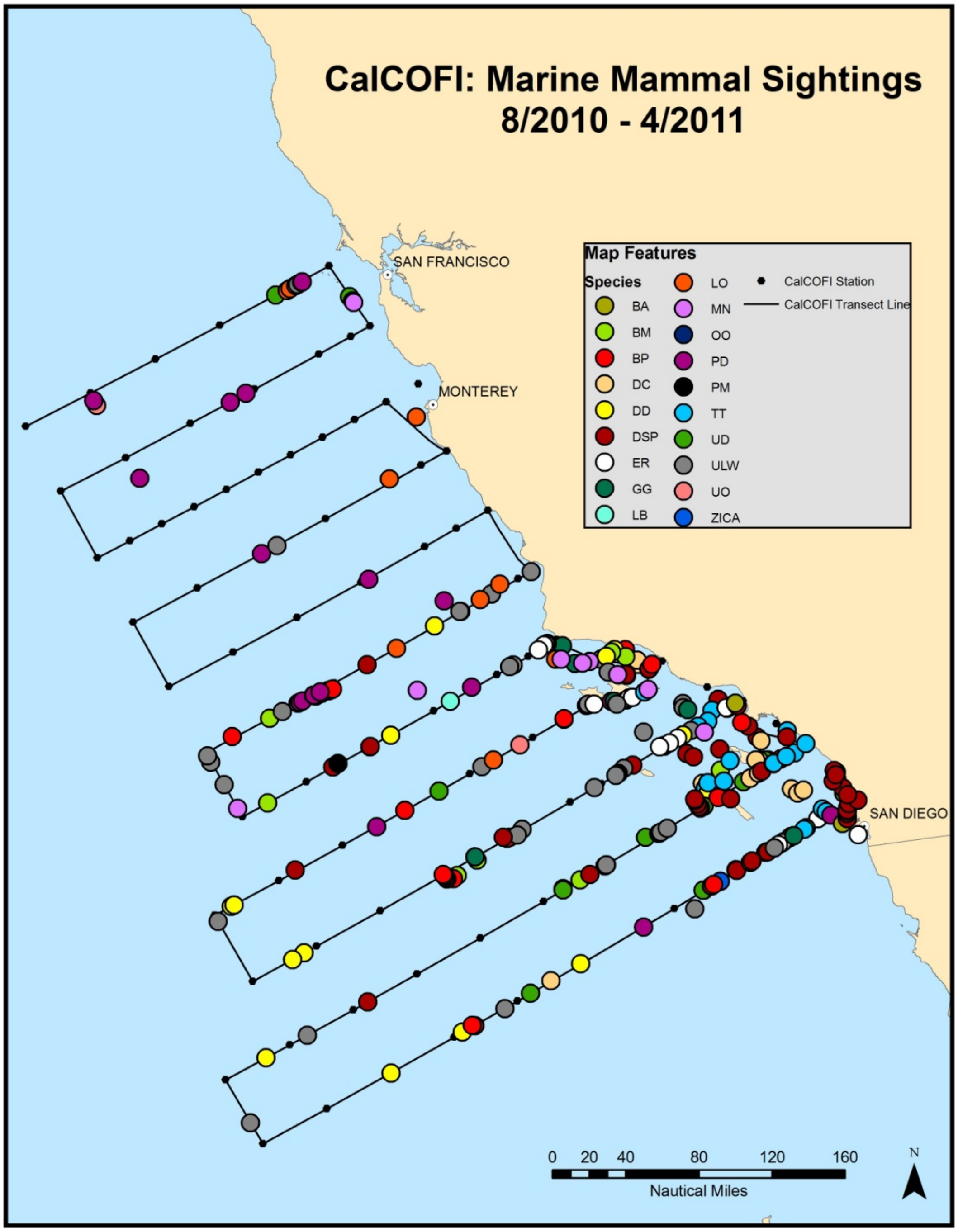

Figure 2. Cetacean sightings by species from four CalCOFI cruises between August 2010 and April 2011.

Table 1. Summary data from four CalCOFI cruises between July 2010 and April 2011.

CalCOFI Cruise Dates	Survey Effort (hrs)	Distance Surveyed (nm)	Number of Cetacean Sightings	Number of Individuals	Number of Digital Photos	Number of Acoustic Array Recordings	Total Hours of Array Recordings	Number of Acoustic Detections /Species	Number of Sonobuoys Deployed	Number of Sonobuoy Detections/ Species	Total Hours of Sonobuoy Recordings
30 Jul - 18 Aug 2010	105	997	90	4,203	665	32	92	95/6	59	54/6	202
28 Oct - 15 Nov 2010	82	582	29	2,827	622	19	64	50/4	38	12/3	112
12 Jan - 6 Feb 2011	126	802	74	1,659	200	33	94	33/5	67	26/3	141
8 Apr - 26 Apr 2011	142	1,432	75	4,710	1,113	29	70	21/5	57	37/5	97
Totals	455	3,813	268	13,399	2,600	113	320	199/8	221	129/6	552

Table 2. CalCOFI cetacean on-effort sightings by cruise from August 2010 – April 2011. See Appendix 1 for species abbreviation codes. Ns = number sightings; Ni = number individuals

	CC1008 (30 Jul - 18 Aug 2010)		CC1011 (28 Oct -15 Nov 2010)		CC1101 (12 Jan - 6 Feb 2011)		CC1104 (8 Apr - 26 Apr 2011)	
Species	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**
Ba	0	0	1	1	2	2	1	1
Bm	10	17	0	0	1	2	3	5
Bp	19	28	1	1	0	0	6	40
Dc	7	409	5	1096	2	137	1	61
Dd	8	997	0	0	3	474	3	502
Dsp	22	2202	6	470	1	140	23	3852
Er	0	0	0	0	19	42	0	0
Gg	2	17	0	0	3	49	1	8
Lb	0	0	0	0	0	0	1	32
Lo	0	0	1	55	6	46	3	104
Mn	0	0	0	0	3	6	5	5
Oo	0	0	0	0	1	1	0	0
Pd	0	0	0	0	15	129	2	23
Pm	0	0	0	0	2	36	2	17
Sc	0	0	0	0	0	0	0	0
Tt	3	36	7	211	6	54	2	22
UD	4	470	4	165	6	535	2	9
ULW	14	18	3	3	4	6	20	29
Zcav	1	9	1	5	0	0	0	0
TOTALS	90	4203	29	2007	74	1659	75	4710

Seasonal variations in visual detection rates as a function of species were apparent. Ninety-three percent of blue whale sightings and 96% of fin whale sightings occurred in spring and summer. Gray whales were only sighted during the winter cruise and humpback whales were only seen during winter and spring surveys. Pacific white-sided dolphins were observed in all seasons except summer with 90% of all sightings in winter and spring. Sperm whales and Dall's porpoise were only sighted during fall and winter cruises. There was no apparent seasonal pattern to sightings of bottlenose, common and Risso's dolphins, though Risso's dolphins were not detected during the fall survey.

The geographic distribution of cetacean species encountered in the CalCOFI study area was not uniform. Spatial patterns of mysticete and odontocete sightings reveal noteworthy variations in the distribution of several common species (Figures 3 and 4). Blue and fin whales had a wide distribution with sightings throughout the study area ranging from coastal to pelagic waters. Humpback whales were seen primarily on the shelf, with the highest concentration in shallow regions around the Channel Islands. Gray whales were sighted exclusively in shelf waters, generally shoreward of the Channel Islands. Short-beaked common dolphins were seen throughout the study area, while long-beaked common dolphins were seen primarily in coastal regions and around the Channel Islands. Bottlenose and Risso's dolphins were generally sighted on the shelf, near islands and close to shore and only occasionally in more offshore waters. Pacific white-sided dolphins were observed in shelf waters ranging from nearshore to the shelf-break with no defined north-south gradient. Dall's porpoise were seen throughout the northern portion of the study area, and sperm whales were found only in deep offshore waters.

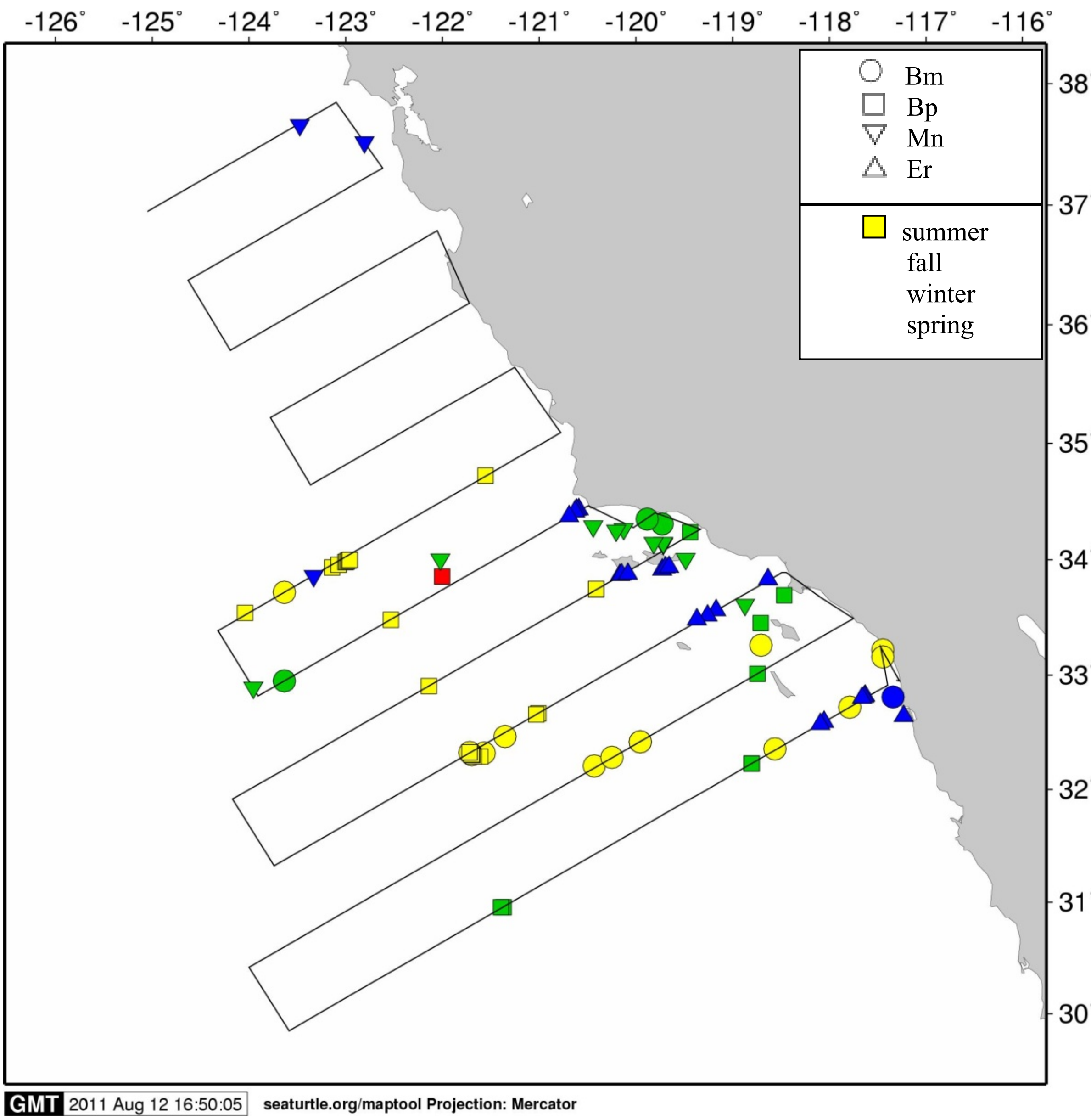

Figure 3. Visual sightings of blue, fin, humpback and grey whales by season from four CalCOFI cruises between August 2010 and April 2011.

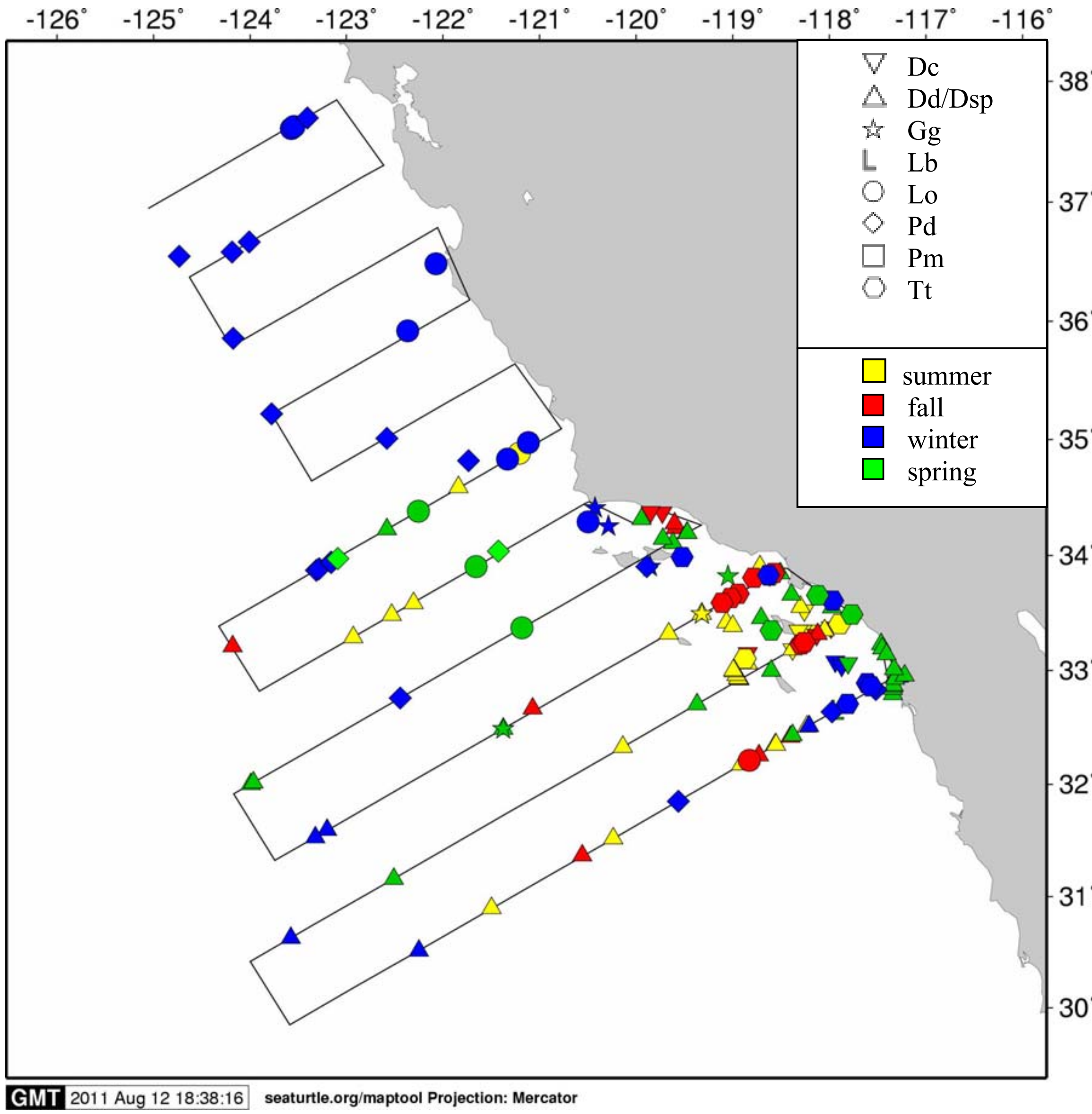

Figure 4. Visual sightings of eight odontocete species by season from four CalCOFI cruises between August 2010 and April 2011.

The relative abundance of baleen whales showed a different trend with noteworthy increases from previous years for three of four common baleen whale species. Fin, humpback, and gray whales had seasonal sighting rates that were the nearly double the average, representing the second highest levels observed for the three species across the seven-year study period (Figure 7). The seasonal increases in relative abundance observed for fin, gray and humpback whales may be an indicator of greater productivity in the southern California Bight in 2010-2011 as compared with previous years. Further examinations of direct metrics of primary productivity such as SST and chlorophyll levels and secondary productivity such as plankton and small fish abundance are needed to better assess potential relationships between baleen whale abundance and pertinent habitat variables.

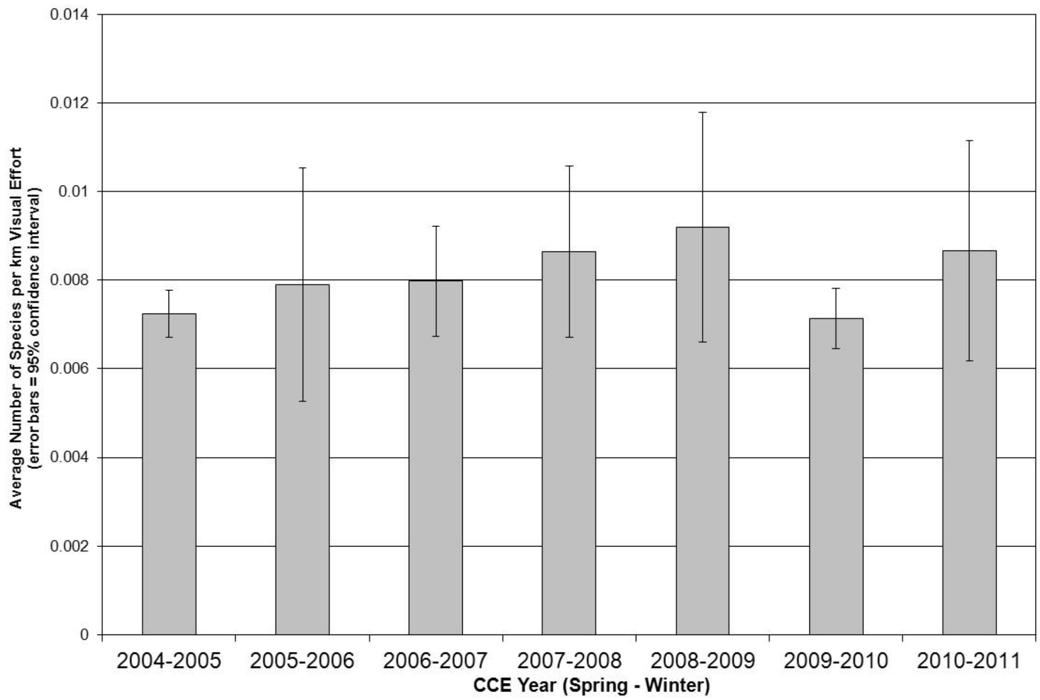

Figure 5. Average species richness (number of cetacean species per km of survey effort) per year (spring – winter). Error bars indicate the 95% CI.

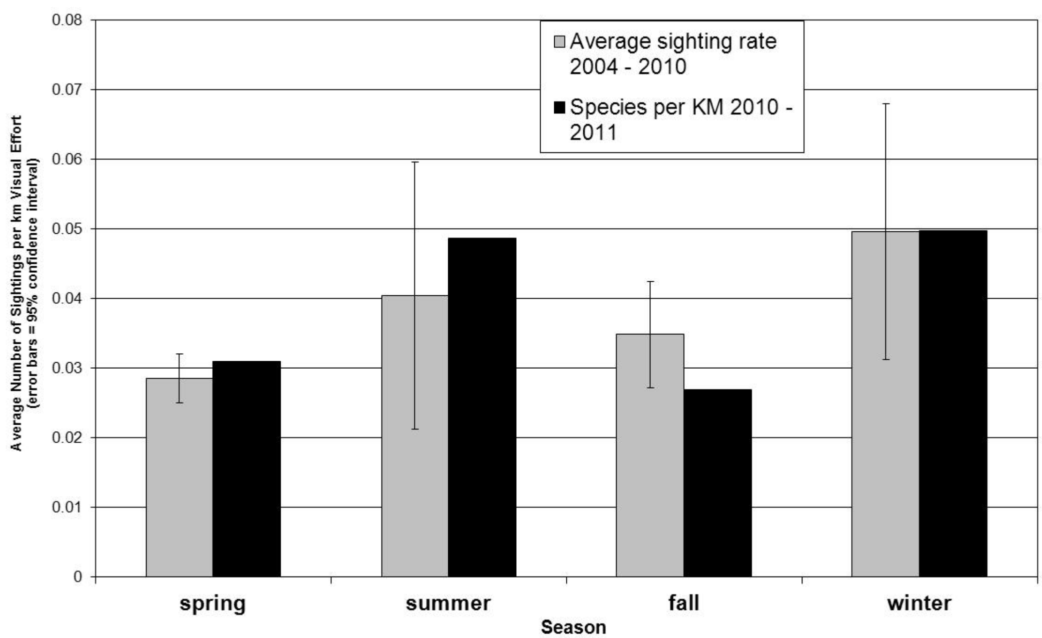

Figure 6. Comparison of the average sighting rates (number of sightings per km visual effort) for July 2004-January 2010 (grey) and the average sighting rates for spring 2010 - winter 2011 (black). Error bars show 95% CI.

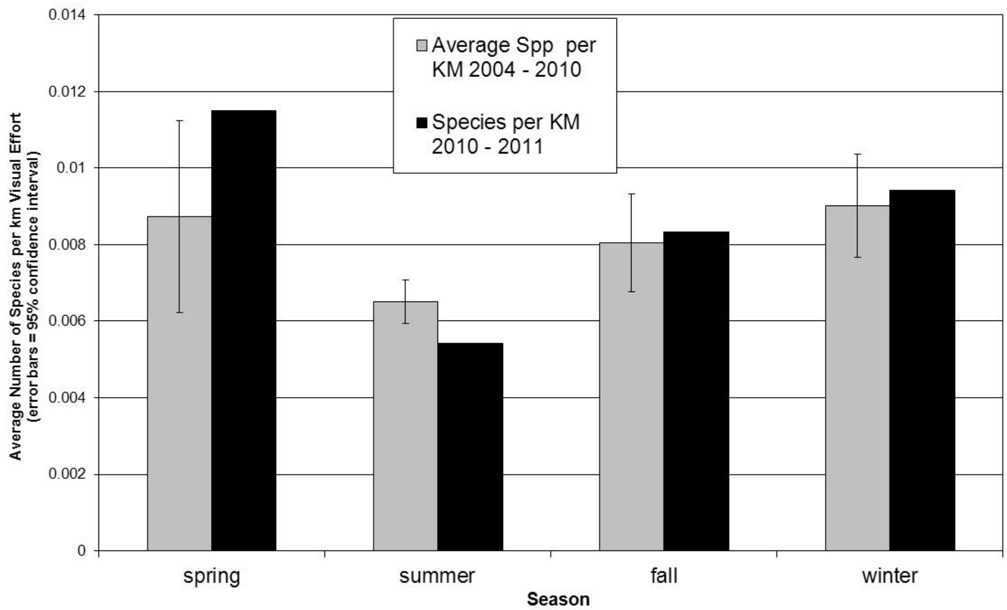

Figure 7. Comparison of the average species richness (number of cetacean species per km of survey effort) for July 2004-January 2010 (grey) and the average sighting rates for spring 2010 - winter 2011 (black). Error bars show 95% CI.

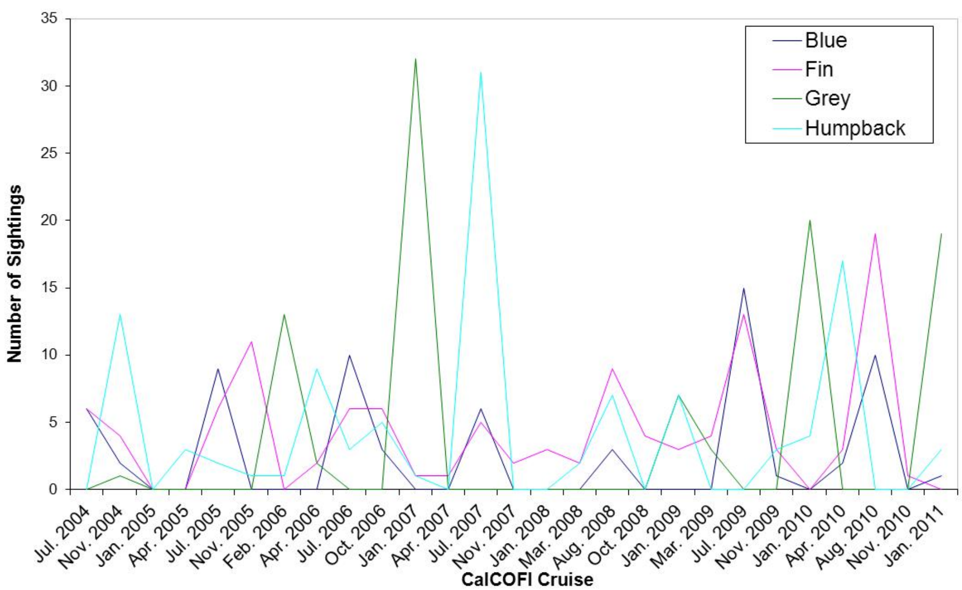

Figure 8. Relative abundance (in number of sightings per cruise) of blue, fin, grey and humpback whales species from July 2004 – January 2011.

Acoustic Monitoring – Towed Array

Acoustic detections from the towed array included 8 odontocete species encompassing a total of 199 detections (Figure 9). Acoustic detection rates varied by species. Of the 199 cetacean acoustic detections, unidentified whistling delphinids comprised 50% (n=99), sperm whales accounted for 19% (n=38), common dolphins 10% (n=20), unidentified clicking delphinids 6% (n=12), Pacific white-sided dolphins 3% (n=6), bottlenose dolphins 2% (n=3), Risso's dolphins 1% (n=1), Cuvier's beaked whales 1% (n=1) and northern right-whale dolphins 1% (n=1). Sperm whale acoustic detections outnumbered visual detections by a factor of nine (38 to 4), reinforcing the utility of using acoustics to document the presence of deep-diving odontocetes.

Spatial patterns in sperm whale and delphinid acoustic array detections were apparent for some species (Figure 9). Sperm whale detections were concentrated in deep pelagic waters as well as slope and shelf waters westward of islands and coastal regions. This spatial pattern of array-based detections of sperm whales is similar to the distribution of visual and sonobuoy detections for this species. Bottlenose and Risso's dolphin detections occurred inshore of the Channel Islands mirroring the visual pattern of detections for these two species. Unidentified whistling and clicking delphind detections were dispersed throughout the study area with the exception of the immediate coastline. The wide distribution and frequent occurrence of unidentified whistling delphinds in the study area, in accordance with the infrequent visual sightings of other whistling species, suggests that the majority of these detections are common dolphins. Further development of our whistle classification algorithms should assist in assigning species identification to these unidentified whistles.

Acoustic Monitoring – Sonobuoys

Real-time acoustic detections from the sonobuoys included four mysticete and two odontocete species encompassing a total of 129 detections (Figures 10 and 11). Acoustic detection rates in the study area varied by species. Of the 129 cetacean acoustic detections, sperm whales comprised 23% (n=30), humpback whales accounted for 19% (n=25), fin whales 18% (n=23), blue whales 10% (n=13), unidentified baleen whales 16% (n=21), and unidentified dolphins 12% (n=16).

Seasonal variations in call detection rates as a function of species were apparent. Humpback whales were frequently detected visually but rarely acoustically inshore in spring and fall, whereas humpbacks were detected acoustically but not visually offshore during winter cruises. Blue and fin whale calls were regularly documented during summer and fall while acoustic detections of these species were rare during winter and fall cruises. Visual detections of blue and fin whales exhibited similar seasonal occurrence patterns, suggesting that acoustic monitoring of these two baleen whale species provides a useful metric for assessing presence/absence in the study area. Sperm whale clicks were detected in all seasons except fall with the majority of detections occurring during the spring cruise. Visual detections of sperm whales were limited to two each during the winter and spring cruises, limiting comparative analysis between visual and acoustic methods for this species. Delphinid calls were heard on all cruises without a clear seasonal pattern.

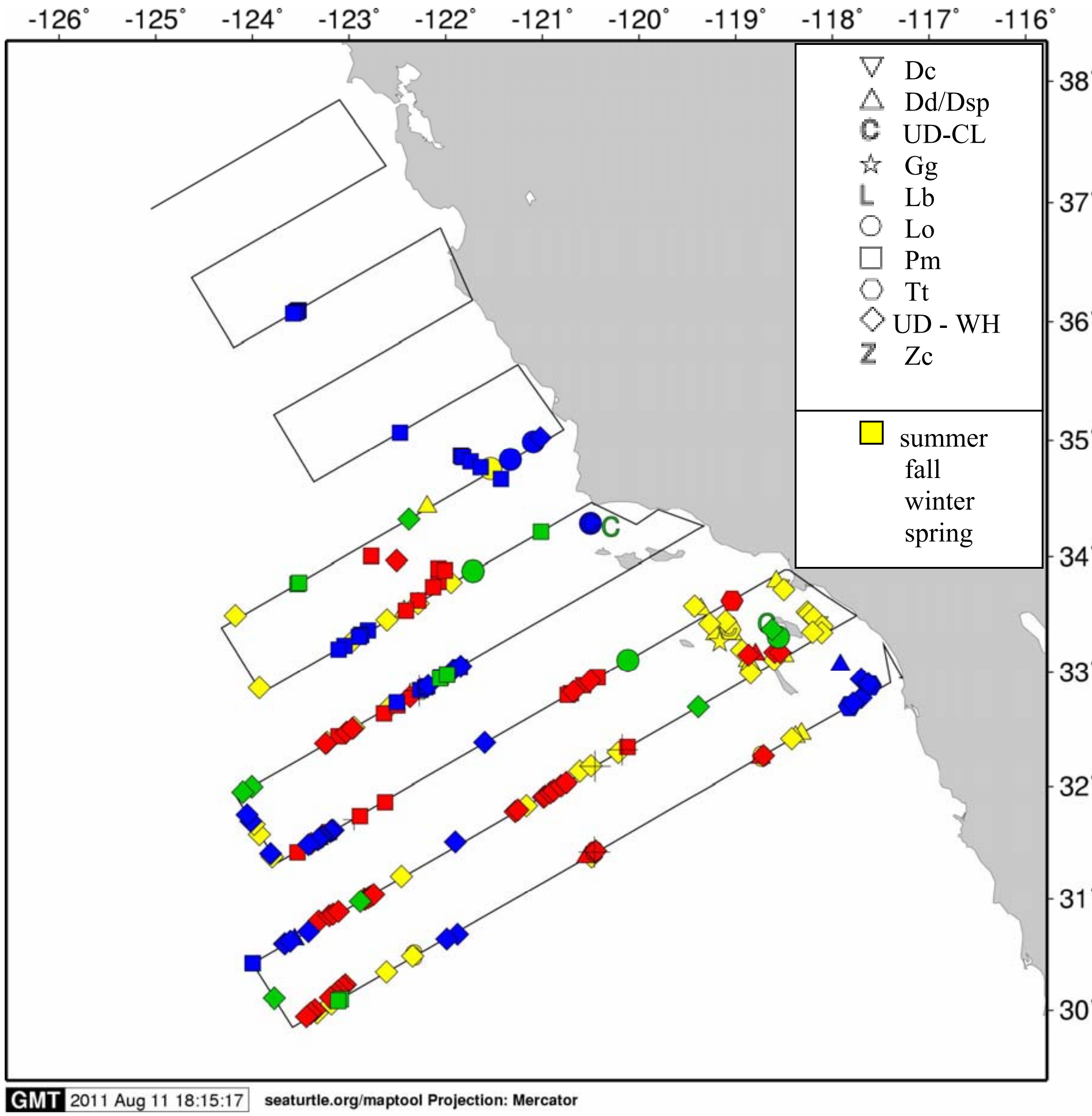

Figure 9. Towed acoustic array detections of odontocete cetaceans by species and season from CalCOFI cruises between August 2010 and April 2011.

Spatial patterns in blue whale, fin whale, humpback whale, sperm whale and delphinid acoustic detections for sonobuoys were also present (Figures 10, 11, and 12). Blue whale, fin whale, humpback whale and delphind detections were dispersed throughout the study area with no apparent spatial pattern. Sperm whale calls were concentrated on deep pelagic stations as well as slope and shelf waters westward of islands and coastal regions.

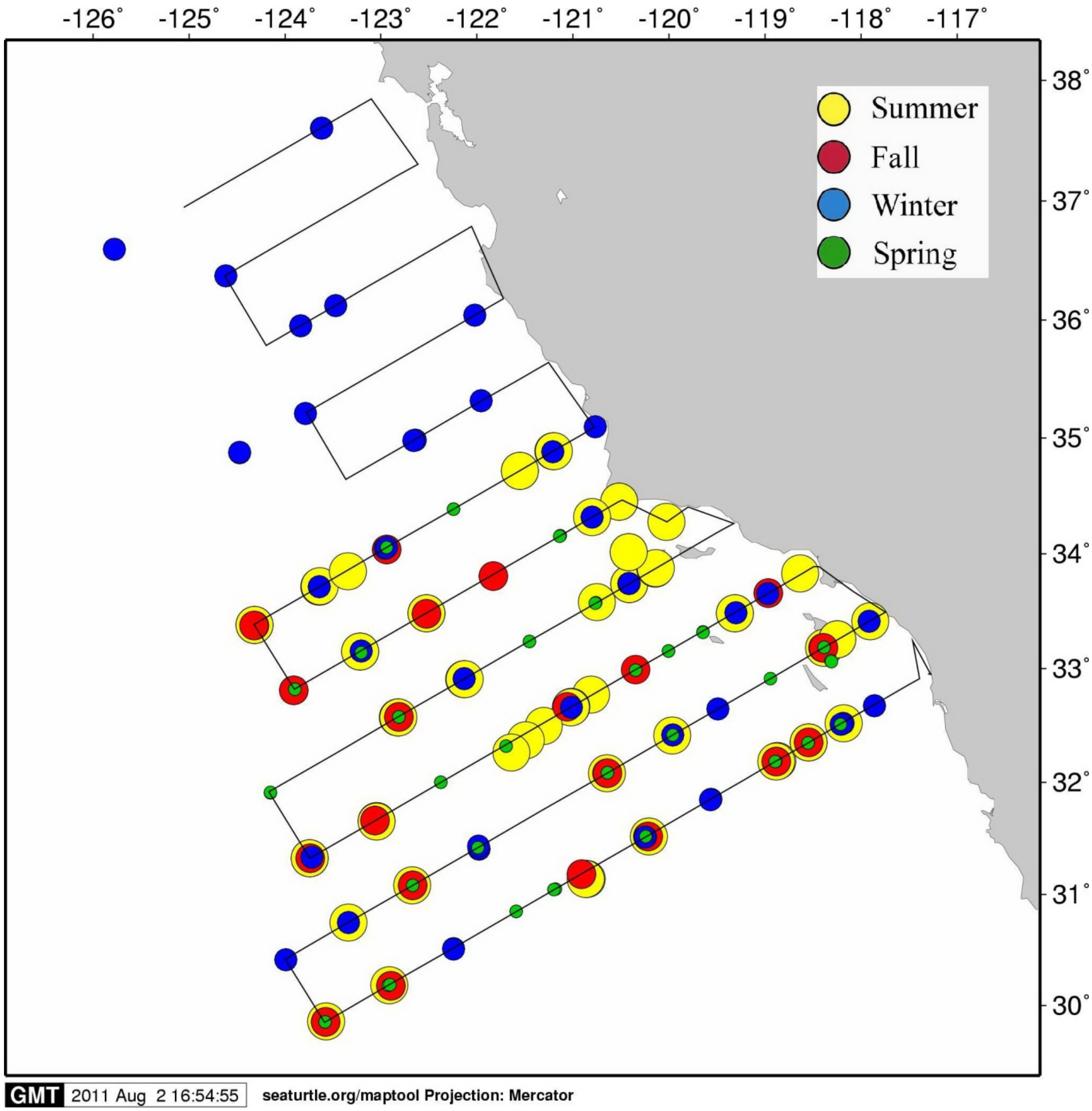

Figure 10. Sonobuoy deployment locations by season from CalCOFI cruises between August 2010 and April 2011. Circle diameter adjusted for visibility on plot and does not reflect amount of effort.

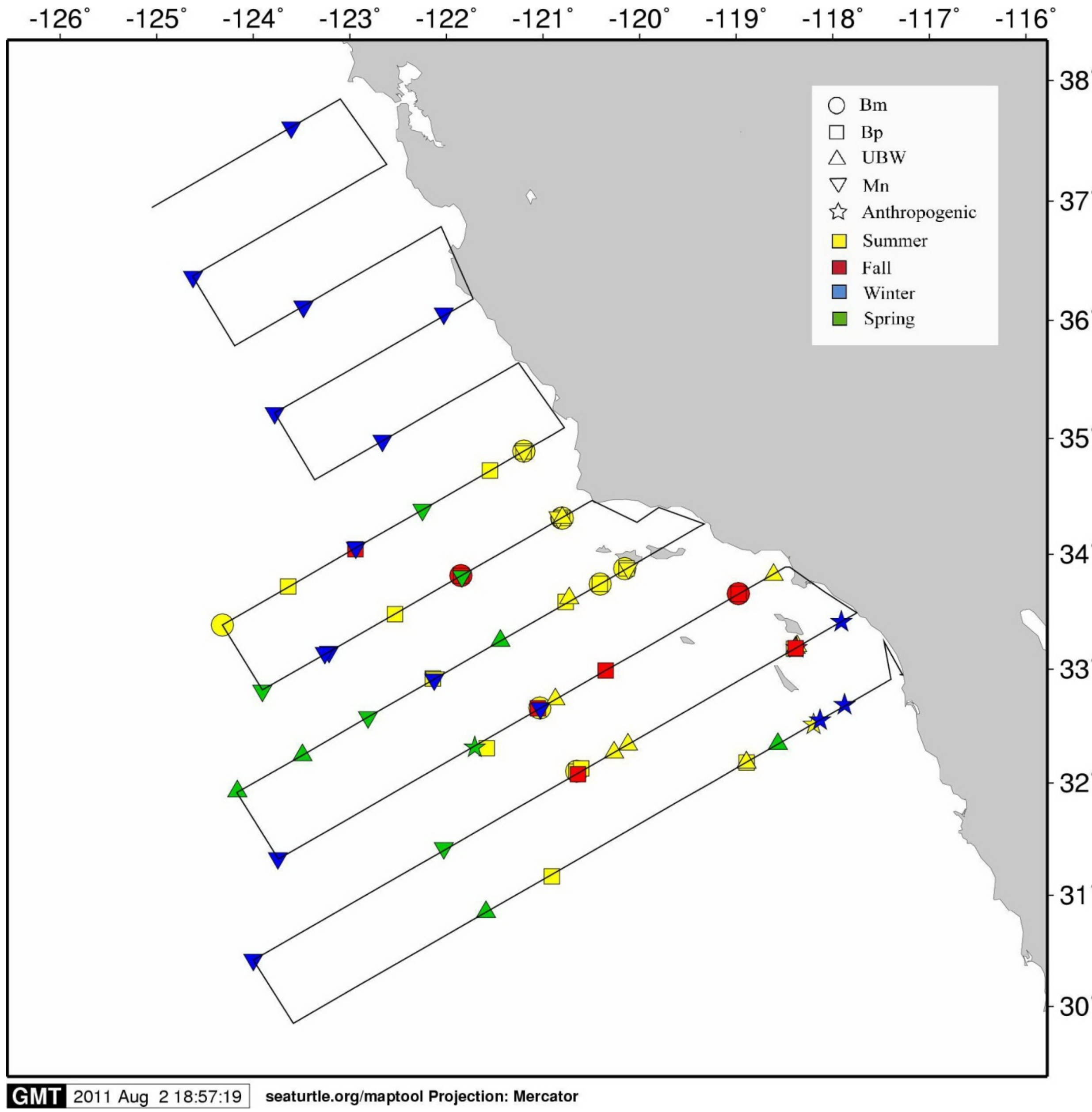

Figure 11. Sonobuoy acoustic detections of mysticete cetacean calls and anthropogenic noise by species and season from CalCOFI cruises between August 2010 and April 2011.

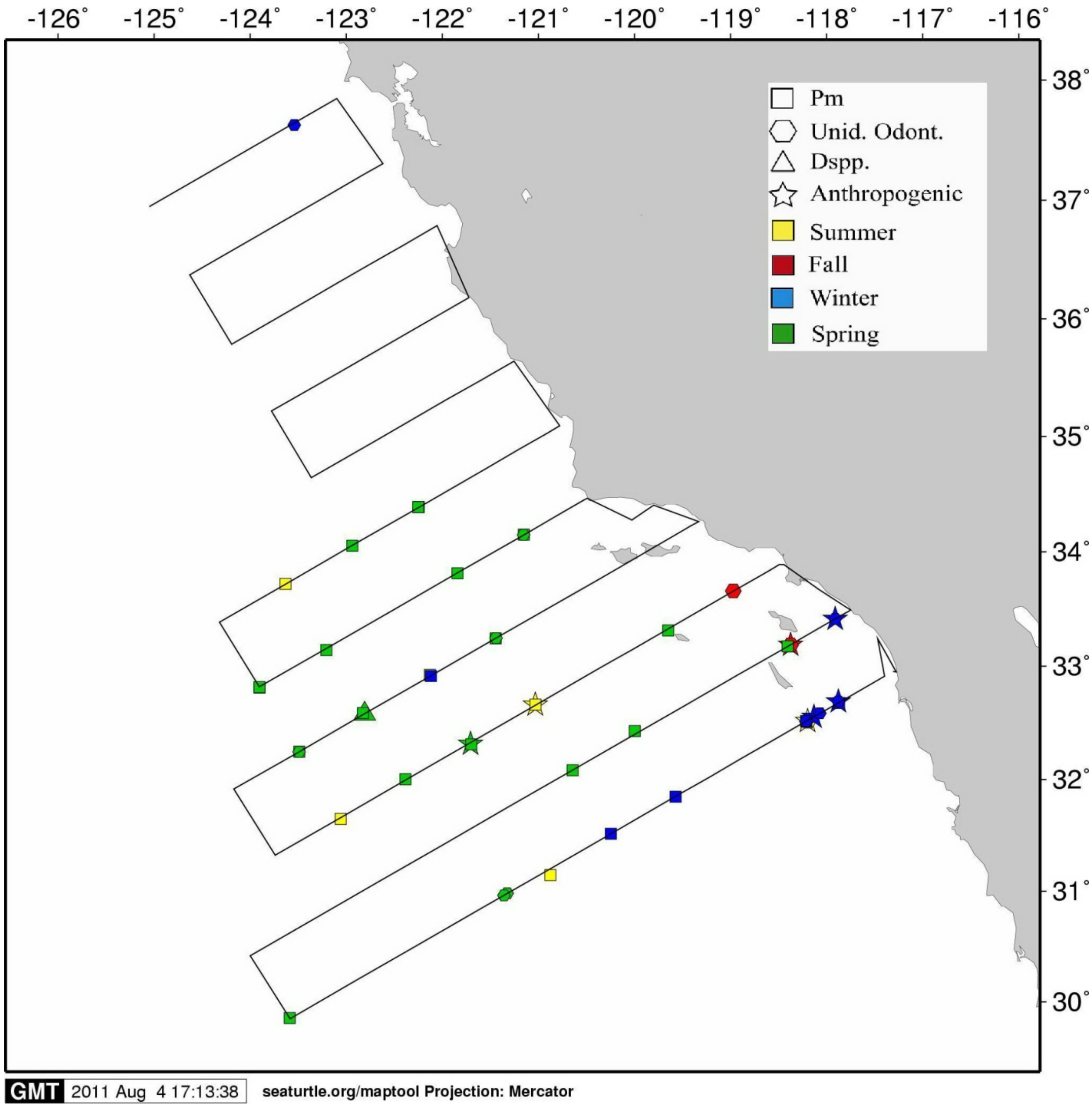

Figure 12. Sonobuoy acoustic detections of odontocete cetacean calls and anthropogenic noise by species and season from CalCOFI cruises between August 2010 and April 2011.

CONCLUSIONS

Marine mammal monitoring on CalCOFI cruises has been conducted over the last seven years to investigate cetacean distribution patterns relative to habitat, to make seasonal estimates of cetacean density and abundance, and to quantify differences in vocalizations between cetacean species. Over the last year, efforts to accomplish these objectives have expanded through incorporating novel analysis approaches, integrating new hardware/software tools, and developing collaborations with other experts in the field. Habitat modeling efforts have been improved through integration of a larger suite of environmental variables collected from CalCOFI cruises, satellite imagery, and autonomous gliders as well as the utilization of innovative GIS-based software tools. The development of density and abundance estimates for nine cetacean species in the CalCOFI study area are currently the focus of an extensive line-transect analysis and spatio-temporal modeling effort, in collaboration with St. Andrews University. Acoustical census techniques for cetaceans have been improved through recently published advancements in acoustic species-identification, localization software, and group size estimation. Cetacean surveys on CalCOFI cruises provide an avenue to examine seasonal and inter-annual patterns in distribution as well as density and abundance on a longer continuous time scale with a higher rate of sampling than previous cetacean surveys off the California coast. The insight gained from these analyses will provide data for environmental assessments and ultimately management protocols.

ACKNOWLEDGEMENTS

Many individuals have made this research possible. We thank CalCOFI and SWFSC scientists Dave Wolgast, Jim Wilkinson, Amy Hays, Dave Griffith, Grant Susner; ship crew, research technicians, and MARFAC Staff. We appreciate the assistance with data analysis and processing provided by Alex Kesaris. We are grateful to Frank Stone and Curt Collins for supporting our work through CNO-N45 and the Naval Postgraduate School.

Appendix A. Species codes for all cetaceans included in report.

SPECIES CODE		
Ba = *Balaenoptera acutorostrata*	Er = *Eschrichtius robustus*	Pd = *Phocoenoides dalli*
(minke whale)	(grey whale)	(Dall's porpoise)
Bm = *Balaenoptera musculus*	Gg = *Grampus griseus*	Pm = *Physter macrocephalus*
(blue whale)	(Risso's dolphin)	(sperm whale)
Bp = *Balaenoptera physalus*	Lb = *Lissodelphis borrealis*	Tt = *Tursiops truncatus*
(fin whale)	(N. right-whale dolphin)	(bottlenose dolphin)
Dc = *Delphinus capensis*	Lo = *Lagenorhynchus obliquidens*	Zcav = *Ziphius cavirostris*
(long-beaked common dolphin)	(Pacific whiste-sided dolphin)	(Cuvier's beaked whale)
Dd = *Delphinus delphis*	Mn = *Megaptera noveangliae*	UD = unidentified dolphin
(short-beaked common dolphin)	(humpback whale)	ULW = unidentified large whale
Dspp = *Delphinus spp.*	Oo = *Orcinus orca*	UO = unidentified odontocete
(unid. Common dolphin)	(killer whale)	

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SIO small boat based marine mammal surveys in Southern California: Report of Results for August 2010 - July 2011

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INTRODUCTION

This report summarizes small boat based research conducted on cetaceans off southern California by the Scripps Institution of Oceanography (SIO) in collaboration with Southwest Fisheries Science Center (SWFSC) from August 2010 – July 2011. The primary objectives of this research were to use sighting, photo-identification, biopsy and acoustical sampling techniques to assess the occurrence, distribution and population structure of small cetaceans in a region that is subject to frequent naval exercises; this information is needed to evaluate possible effects from Mid Frequency Active Sonar (MFAS) trials and ultimately for the development of appropriate management protocols. Survey effort was focused on the Southern California Offshore Range (SCORE) near San Clemente Island as part of an ongoing collaborative study to assess cetacean populations occurring in this active Navy training area (Moretti *et al*. 2006; Falcone *et al*. 2009). Additional surveys were conducted at Catalina Island and the San Diego coastline. This geographically broad approach was designed to increase the effectiveness of our monitoring efforts by collecting similar data at multiple sites, providing a regional assessment of small cetacean populations inhabiting the area.

While the current SIO/SWFSC small boat effort in southern California incorporates data collection from all cetacean species encountered, bottlenose and Risso's dolphins were selected as initial focal species due to their accessibility, existing baseline data and varying life history patterns. The information provided herein provides an outline of our research goals and preliminary results from efforts during 2010/2011.

METHODS

Survey Effort

SIO small vessel surveys were conducted at San Clemente and Catalina Island from 4-11 January 2011, 1-7 May 2011, and 21–25 July 2011. In addition, nineteen surveys were conducted along the San Diego coastline during this same time period. Surveys were conducted from a 6.8 m rigid-hulled inflatable boat (RHIB) equipped with twin outboard engines. Survey tracks from the field effort at the three study sites are presented in Figure 1.

STUDY AREAS

San Clemente Island

San Clemente Island surveys were based from Wilson Cove on the north-eastern corner of the island; approximately 22 km from the Navy's SOAR array located west of the island (see Figure 1). Survey routes were neither systematic nor random as weather, range restrictions, directed acoustic detections, and *a priori* knowledge of focal species distribution were all factors in determining the route for a given day. Survey efforts on the SOAR range in conjunction with M3R-based acoustic detections (Moretti *et al*. 2006) were conducted in sea state Beaufort 3 or less. When prevailing north-westerly winds created unfavorable sighting conditions or naval operations precluded access to the SOAR range, survey efforts were focused on the lee (eastern) side of the island where frequent sightings of bottlenose, Risso's and common dolphins have been documented (Caretta *et al*. 2000).

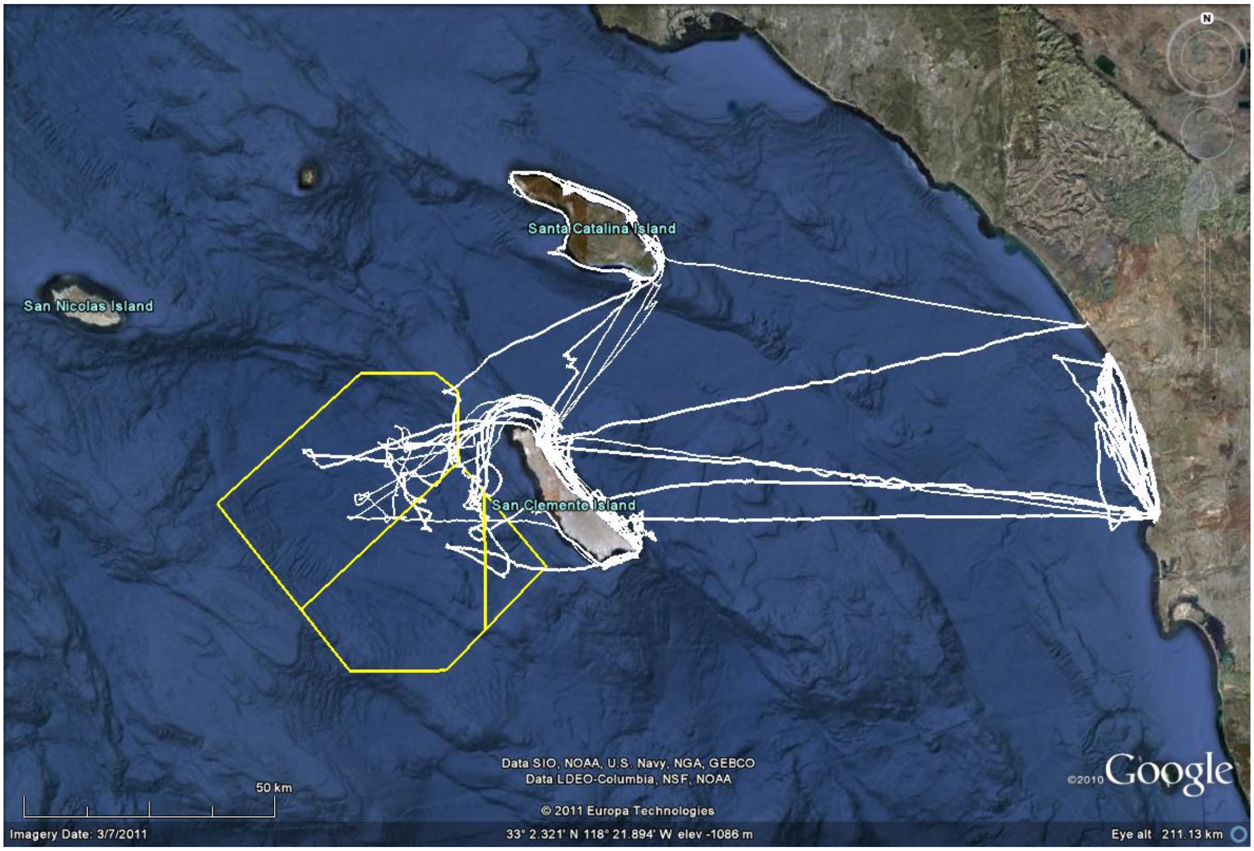

Figure 1. SIO small vessel survey tracks from monitoring at SCORE (boundaries of SOAR range in yellow), Catalina Island and the San Diego coastline from August 2010 – July 2011.

Catalina Island

Catalina Island surveys were based from Avalon on the south-eastern corner of the island (Figure 1). Survey routes were designed to provide systematic coverage of the study area via circumnavigation of the island at a distance of approximately 2 km from shore. When weather conditions precluded our ability to complete a circumnavigation of the island, we employed opportunistic effort to cover areas that had suitable weather and sighting conditions.

San Diego Coastline

The San Diego coastal study area encompassed a 32 km strip of coastline between Scripps Pier and Carlsbad. Surveys of immediate coastal waters were conducted in a systematic manner using methods developed and applied by researchers from San Diego State University since 1984 (see Defran and Weller 1999). When sampling in coastal waters was completed, surveys progressed 12-16 km offshore where there was a greater probability of encountering species common to the two offshore island study areas (e.g. offshore bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins).

PROCEDURE

When cetaceans were sighted, the group was approached and information on species, group size and composition, direction of movement, environmental conditions, latitude/longitude and time was recorded. For bottlenose and Risso's dolphins as well as beaked whales and baleen whales, effort was made to acquire numerous quality photographs of each individual present for individual identification. Biopsy samples were collected from particular species for current/planned projects being conducted by SIO and/or our collaborators at SWFSC. Acoustical recordings of select species calls as well as anthropogenic sounds were conducted opportunistically. Details on the instrumentation utilized and specific protocols for each method of data collection are outlined below.

Photo-Identification

Photo-identification data were collected using a Canon EOS 50D digital SLR camera equipped with a 100-400 mm Canon EF image-stabilizing lens. Effort was made to acquire numerous quality photographs of dorsal fins, tail flukes and/or lateral flanks (depending on the species) of each individual encountered, without regard to apparent distinctiveness. After completion of photographic effort, the vessel was positioned for acoustical recordings and/or biopsy sampling (see below). Identical procedures were repeated when additional cetacean groups were encountered.

Biopsy Sampling

Biopsy sampling was conducted with a Barnett Panzer crossbow delivering a carbon biopsy dart with modified tip. The custom built tip was 25 mm in length with a 7 mm diameter circular end and contained three to four internal barbs designed to retain the tissue sample. Samples were labeled in the field according to species, date, and location and placed on ice while on the research vessel. Upon completion of a given survey, samples were temporarily stored at -20°C until transfer to the Southwest Fisheries Science Center for archiving and permanent storage at -80°C.

Drop-Hydrophone Recording System

Acoustical recordings were collected from the RHIB using a mobile, compact hydrophone and recording system. The acoustic sensor consists of two transducers connected to a signal conditioning circuit board encased in a 5 cm oil-filled tube. To allow for broadband data collection and to reduce electronic noise, the circuit board was divided into two stages covering different frequency bands. The stage one frequency band is 10 – 3000 Hz and utilizes six Benthos AQ-1 cylindrical hydrophones in series. The stage two frequency band ranges from 2000 – 100,000 Hz and uses a single omni-directional, spherical SRD HS-150 hydrophone with a flat frequency response (±3 dB) from 1 to 100 kHz.

The analog signals from the circuit boards were digitized and recorded with the Fostex FR-2 field memory recorder. The recording system is capable of sampling two channels at 192 kHz with 24-bit samples, yielding a Nyquist frequency of 96 kHz, with a flat frequency response (±3 dB) from 20 – 80 kHz. Signals were recorded directly to an 8 Gbyte compact flash memory card and subsequently downloaded directly to computer hard-drives.

HARP Recording System

Independent of the small boat operations, we deployed several High-Frequency Acoustic Recording Packages (HARPs) in the basins around San Clemente Island to provide a long-term continuous record of acoustic signals occurring in the region. HARPs are autonomous, bottom mounted instruments containing a single hydrophone tethered 10 m above the seafloor (Wiggins and Hildebrand 2007). The system records signals in the band from 10 Hz to 100 kHz, making it capable of recording a wide variety of sounds ranging from baleen whale calls to MFAS to odontocete echolocation clicks. HARPs are capable of acoustic sample rates of up to 200 kHz and can store 1920 GBytes of acoustic data, allowing continuous recording for 55 days. The HARP can also be duty-cycled (e.g., 20 min on, 10 min off) to extend recording duration. Data collected by HARPs are analyzed for signal content following instrument retrieval using both manual and automated signal recognition methods.

DATA ANALYSIS

Photo-identification

Photo-identification analysis closely followed techniques described by Defran *et al*. (1990) and are summarized as follows: Clear photographs of distinctively marked dorsal fins were sorted by recognizable notch patterns, and the best photograph of each dolphin was selected as the "type photo" to which all other photographs were compared. Subsequently, only unambiguous matches with the "type photo" were accepted as re-identifications of a known individual.

Biopsy Sampling

Tissue samples, collected via biopsy dart, will be analyzed with three primary objectives in mind. To examine population structure, DNA will be extracted using standard molecular protocols with Qiagen DNeasy and genetic sex-determination will be conducted by Real-Time PCR (Stratagene) assay. To assess stress hormone levels, methods to measure blubber cortisol are currently under development (Nick Kellar, SWFSC) and will follow published techniques (Kellar *et al.* 2006; 2009) used to examine reproductive hormones (progesterone and testosterone). Finally, to determine contaminant (DDT, PCBs and PBDEs) levels, standard protocols developed by the Northwest Fisheries Science Center (a collaborator on this aspect of the project) will be followed.

Acoustical Recordings

The structural characteristics of clicks and/or whistles collected in 2010/2011 from five delphinid species are currently being measured and applied to the development of a suite of detection and classification engines. Echolocation clicks are assessed through the calculation of several variables including duration, inter-click interval, peak frequency points, -3dB bandwidth, -10 dB bandwidth and center frequency. Whistle structure analysis entails the extraction of eight specific variables from each whistle contour: begin frequency, end frequency, minimum frequency, maximum frequency, frequency range, mean frequency, duration, and number of inflection points. Call variables are subsequently applied to multivariate statistical engines to examine the within species/population and between species/population variability inherent in the data.

HARP Recordings

The temporal occurrence of MFAS will be assessed from continuous recordings collected at HARP site H simultaneous with small boat surveys at San Clemente Island. MFAS events will be logged based on manual review of long-term spectrograms (LTSAs) containing one hour of acoustical data with a Nyquist frequency of 5 kHz. Event detections documented in the LTSA window will be examined on a finer temporal scale to calculate start and end times, confirm initial signal classification and document the structural characteristics of MFAS signals.

RESULTS

Sightings

Cetacean sightings across the three study areas included six odontocete and five mysticete species. Excluding common dolphins, bottlenose dolphins were the most commonly sighted species at Catalina Island and off the San Diego coastline while Risso's dolphins were the most frequently encountered cetacean at San Clemente Island. Humpback whales were the least frequently encountered species with only one sighting during the period. Plots of all cetacean sightings documented during the 2010/2011 study period are presented in Figure 2. Additional details on sighting, photo-identification, acoustical and biopsy data collected from the three study areas are provided in Tables 1 through 4.

The distribution of cetacean species sighted off San Clemente Island was not uniform (Figure 2). Bottlenose and Risso's dolphin sightings were concentrated in near-shore waters with a mean distance from the island of 3.8 km and 6.4 km respectively. One-hundred percent of bottlenose and 75% of Risso's dolphin sightings occurred off the SOAR range with the remaining four sightings of this species occurring on the eastern portion of the range. Sightings of fin whales and Dall's porpoise were made exclusively on the SOAR range.

San Diego Coastal Surveys

Between 1 August 2010 and 30 July 2010, a total of nineteen surveys were conducted along the San Diego coastline. These surveys represent one component of a larger field effort on California coastal bottlenose dolphins extending from 2 November 2009 to 19 April 2011, encompassing a total of 31 surveys. Overall, 115 groups, composed of approximately 958 individuals, were approached for photo-identification purposes. Analysis of photo-identification data has been completed for the first 19 surveys of the study, resulting in a catalog of 210 unique individuals. The remaining photo analysis is underway and expected to be completed in September. Upon completion of this component of the project, mark-recapture abundance analysis will be initiated.

Appendix 1 provides survey-specific summaries for each day of effort on our coastal surveys. These summaries include information on survey effort, plots of sighting locations and survey tracks, and tabular summaries of the species encountered, number of individuals in each group, number of photo- and the number of acoustic recordings and biopsy samples obtained.

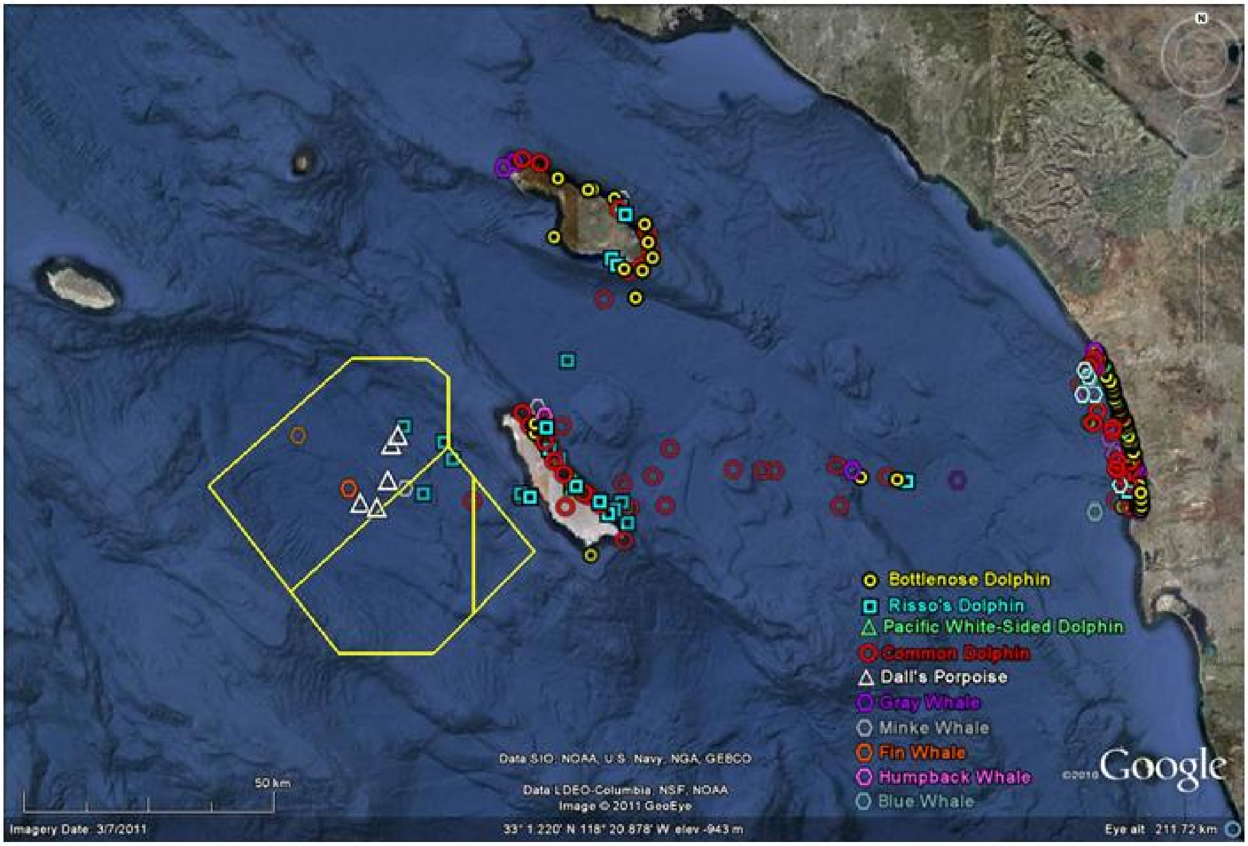

Figure 2. Cetacean sightings documented on all SIO small boat surveys in southern California from August 2010 – July 2011.

Table 1. Summary sighting, photo-identification, acoustical and biopsy data collected January 4-11, 2011 at San Clemente and Catalina Islands.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	13	314	1939	7	4
Risso's Dolphin	6	127	612	1	2
Pacific White-Sided Dolphin	-	-	-	-	-
Short-Beaked Common Dolphin	3	1638	5	-	-
Long-Beaked Common Dolphin	2	256	12	-	-
Dall's Porpoise	5	29	141	-	-
Fin Whale	1	1	10	-	-
Humpback Whale	1	2	-	-	-
Gray Whale	3	4	81	-	-
Blue Whale	-	-	-	-	-
Minke Whale	-	-	-	-	-

Table 2. Summary sighting, photo-identification, acoustical and biopsy data collected May 1-6, 2011 at San Clemente and Catalina Islands.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	3	54	384	3	8
Risso's Dolphin	8	331	1873	9	3
Pacific White-Sided Dolphin	1	10	17	-	-
Short-Beaked Common Dolphin	20	3613	90	-	-
Long-Beaked Common Dolphin	8	434	97	-	-
Common Dolphin, species unknown	2	31	0	-	-
Fin Whale	1	7	211	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	1	2	33	-	
Blue Whale	-	-	-	-	-
Minke Whale	2	2	126	-	-

Table 3. Summary sighting, photo-identification, acoustical and biopsy data collected July 21-25, 2011 at San Clemente Island.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	8	100	753	2	3
Risso's Dolphin	9	185	823	3	2
Pacific White-Sided Dolphin	-	-	-	-	-
Short-Beaked Common Dolphin	14	2114	1	2	-
Long-Beaked Common Dolphin	3	46	-	1	-
Common Dolphin, species unknown	1	450	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	-	-	-	-	-
Blue Whale	3	5	35	-	-
Minke Whale	-	-	-	-	-

Table 4. Summary sighting, photo-identification, acoustical and biopsy data collected August 2010 – July 2011 on nineteen surveys off the San Diego coastline.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Coastal Bottlenose Dolphin	79	729	7592	15	2
Offshore Bottlenose Dolphin	2	18	59	-	-
Risso's Dolphin	1	26	307	-	3
Pacific White-Sided Dolphin	4	29	79	-	1
Short-Beaked Common Dolphin	5	3634	14	-	-
Long-Beaked Common Dolphin	7	1615	43	-	-
Common Dolphin, Species unknown	4	69	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	6	7	34	-	
Blue Whale	10	23	625	-	-

Bottlenose Dolphin Photo-Identification

Based on morphology (Walker 1981), photo-identification (DeDecker *et al*. 1999) and genetics (Lowther 2006), NMFS management protocol delineates bottlenose dolphins off Southern California into two distinct stocks: a coastal stock of approximately 450 animals (Dudzik *et al.* 2006) and an offshore stock of 3,000 animals (Caretta *et al*. 2009). While each of these metrics supports the theory of separate coastal and offshore populations, none provide the resolution necessary to determine if animals occurring on the shelf and/or near islands in the Southern California Bight may be distinct from animals occurring in pelagic waters. Without a clear understanding of offshore bottlenose dolphin population structure in the SOCAL region, it is difficult to define stocks, thus limiting the power of abundance and survivorship estimates (Duffield *et al*. 1983, Ross and Cockroft 1990, Curry and Smith 1998). To reliably assess the effects of sources of anthropogenic disturbance, such as MFAS, additional information on the population structure of offshore bottlenose dolphins is needed. The current photo-identification project as well as expanded DNA analysis will fill important data gaps in our understanding of bottlenose dolphin population structure off southern California.

From August 2006 – July 2011, 74 groups of bottlenose dolphins were photographed for individual identification at San Clemente Island, Catalina Island, and in the Gulf of Santa Catalina (Figure 3). Biopsy samples were also collected from 22 of the 74 groups encountered for a total of 65 tissue samples with corresponding individual photo-identifications. Analysis of the combined SIO/SWFSC and Cascadia Research Collective bottlenose dolphin photographic database from August 2006 - May 2011 resulted in a catalog of 419 distinctive individuals from San Clemente Island and 312 individuals from Catalina Island. Photo-identification analysis indicated variable levels of intra- and inter-annual site fidelity to the San Clemente and Catalina Island study areas as well as movement between the two island sites. Mark-recapture abundance estimation models are currently being applied to the database with final results expected in February 2012. Details on the results of our analyses through May 2011 are provided below.

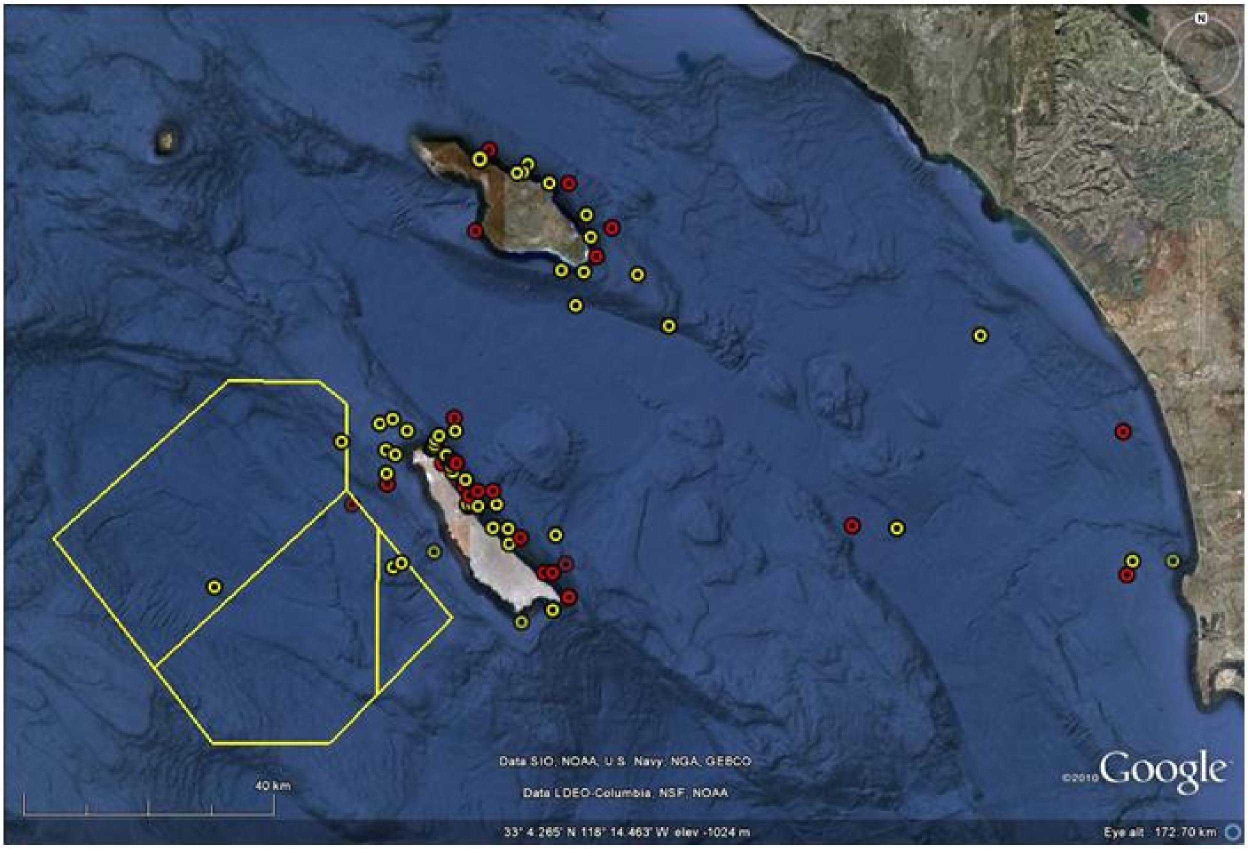

Figure 3. Distribution of offshore bottlenose dolphin sightings from August 2006 – July 2011 where at least one individual was photographically identified; Yellow = Photo-ID, Red = Biopsy and Photo-ID.

Rate of discovery

The rate at which individual dolphins were identified off San Clemente Island from 2006-2011 was examined across surveys in which at least one dolphin was photographically identified (n=29 surveys, Figure 5). Rate of discovery, plotted as the cumulative number of newly identified individuals across each survey, indicates that new (i.e. previously unidentified) individuals were encountered throughout the six-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, 21% (n = 86) of the 419 individuals identified have been sighted in two or more of the eleven survey periods. In addition, the proportion of newly identified individuals decreased from 100% at the beginning of the study to 64% on the most recent survey analyzed (Figure 4). Based on this trend, we expect the overall proportion of newly identified individuals to decrease with additional surveys at San Clemente Island.

The rate at which individual dolphins were identified off Catalina Island from 2006-2011 was examined across surveys in which at least one dolphin was photographically identified (n = 12 surveys, Figure 5). Similar to San Clemente Island, the rate of discovery curve indicates that new (i.e. previously unidentified) individuals were encountered throughout the six-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, 9% (n = 28) of the 312 individuals first identified at Catalina have been sighted in two or more of the eleven survey periods. In addition, the proportion of newly identified individuals decreased from 100% at the beginning of the study to 62% on the most recent survey analyzed. Based on this trend, we expect the overall proportion of newly identified individuals to decrease with additional surveys at Catalina Island.

Sighting frequency and site fidelity

Sighting frequencies for the 419 dolphins first identified at San Clemente Island from 2006-2011 ranged from 1-6 ($\bar{x}$ = 1.5, SD = 0.8). Sixty-nine percent (n = 291) of the dolphins were photographed once, 20% (n = 85) two times, 7% (n = 28) three times and 4% (n = 15) four or more times. Sighting frequencies for the 312 dolphins first identified at Catalina Island from 2006-2011 ranged from 1-6 ($\bar{x}$ = 1.3, SD = 0.6). Seventy-nine percent (n = 249) of the dolphins were photographed once, 18% (n = 55) two times, 2% (n = 5) three times and 1% (n = 3) four or more times.

Re-sightings of the same individuals within one survey period (5-14 days) were frequent, indicating short-term site fidelity to the island study sites. From the total sample of 731 individual bottlenose dolphins, the number of survey periods in which identified individuals were photographed averaged 1.1 survey periods (SD = 0.4, range = 1–4). Eighty-four percent (n = 617) of the identified population was photographed during only one survey period, 13% (n = 98) was observed during two survey periods, 2% (n = 15) was sighted during three survey periods and <1% (n=1) was sighted during four periods (Figure 6). None of the identified individuals were sighted during all eleven survey periods; however, photo-identifications of only 27 individuals were collected in 2006 and 27 individuals were identified in 2007, restricting the number of animals that could have been sighted during all eleven survey periods. In addition, individuals that were identified during the latter part of the study were not present in the photographic catalog for long enough duration to be re-sighted during multiple survey periods.

Inter-Island Movement patterns

Photographic comparisons of 419 dolphins first identified from 2006-2011 at San Clemente Island with the 312 animals first documented at Catalina during the same period resulted in 22 individuals identified in both study areas (Figure 6). Variable patterns of inter-island movements were apparent from the sighting matrix, with sighting intervals between Catalina and San Clemente ranging from 5 days to 5 years. These data represent the first photographically documented movement of bottlenose dolphins between Catalina Island and San Clemente Island.

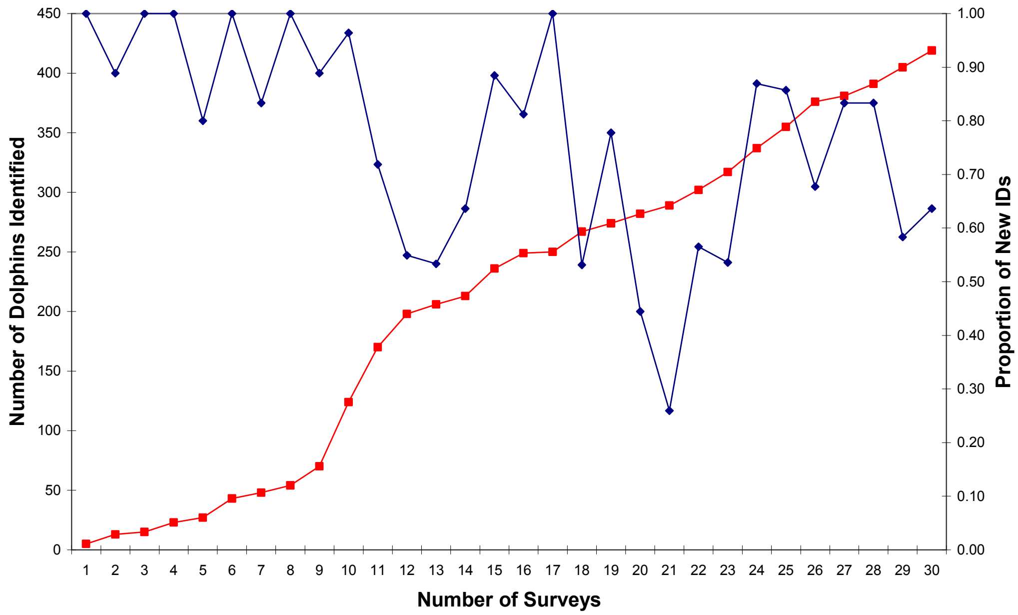

Figure 4. Cumulative number of bottlenose dolphins (red) and the proportion of new individuals photo-identified (blue) at San Clemente Island over 29 surveys in which at least one dolphin was identified. N = 419 individuals.

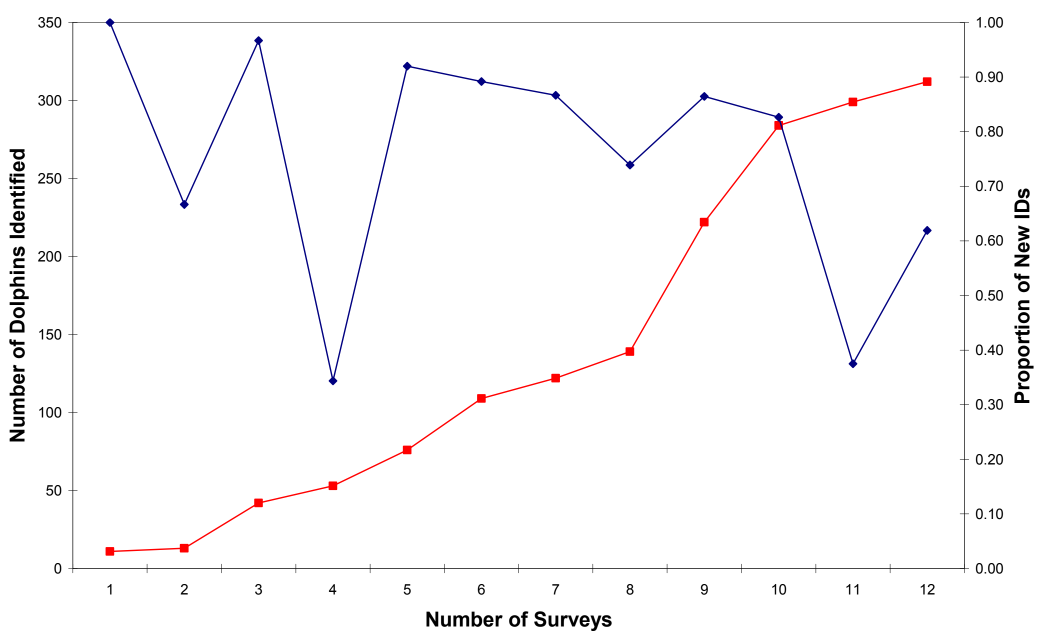

Figure 5. Cumulative number of bottlenose dolphins (red) and the proportion of new individuals photo-identified (blue) at Catalina Island over 12 surveys in which at least one dolphin was identified. N = 312 individuals.

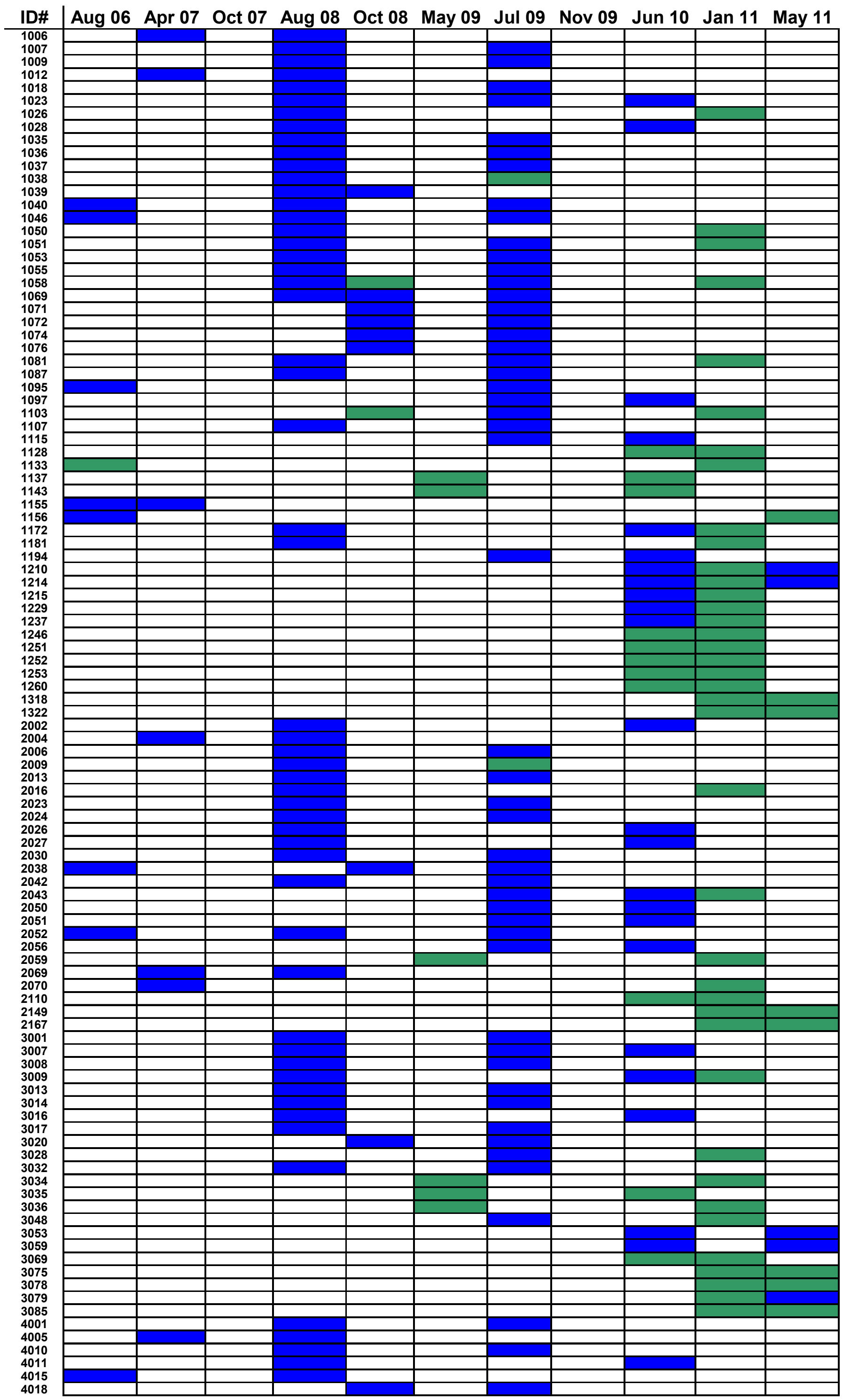

Figure 6. Sighting matrix for the 114 bottlenose dolphins photographically identified during two or more of the 11 survey periods at San Clemente and Catalina Island from August 2006 – May 2011. Blue = SCI; Green = CI.

Bottlenose Dolphin Biopsy Sampling

Biopsy samples taken from bottlenose dolphins at San Clemente and Catalina Islands as well as the San Diego coastline from October 2008 through July 2011 are currently being analyzed by scientists at the NOAA Southwest Fisheries Science Center along three metrics: (1) stress **(cortisol)** and reproductive **(progesterone)** hormone levels relative to Mid Frequency Active Sonar exposure, (2) DNA analyses for an **assessment of the population structure and relative relatedness of coastal, pelagic and island associated bottlenose dolphins in SOCAL and (3) contaminant loads (persistent organic pollutants and mercury) in coastal versus offshore animals.**

Hormone Study

The collaboration between SIO and SWFSC on the San Clemente Island monitoring project led to the incorporation of a recent and developing technique for assessing stress in free-ranging cetaceans. Bottlenose dolphin biopsy samples collected from October 2008 through July 2011 at San Clemente and Catalina Island, as well as off the San Diego coastline, are currently being analyzed by Nick Kellar and colleagues at SWFSC for glucocorticoids (GC) concentrations.

As part of the GC analysis, validation of the protocols used to measure cortisol in cetacean blubber is being conducted, by using bowhead whales (killed by native hunters in Alaska) as voucher specimens. Serum concentrations of cortisol are known for each of these whales and blubber cortisol levels have now been measured in 104 animals. The mean (SE) measured blubber cortisol value was 536 (± 86.8) pg/g and a significant relationship between blubber and serum cortisol levels (R2 = 0.2245 (p = 0.035). Though significant, the relationship is fairly loose; a result that was expected given what is known about the dynamics of blubber cortisol production. The serum levels are quite variable as they are integrated over a short period of time and the events just prior to sampling dominate the levels we measure. Blubber cortisol values are integrated over a longer period of time and therefore the act of sampling itself is much less likely to affect the measured value. Given that these bowhead whales were hunted and killed before being sampled, it is not surprising that the levels were higher in the blood and that the relationship between the two matrices is loosely correlated.

DNA Study

Genetic comparisons between coastal and offshore bottlenose dolphins in the southern California Bight support the existence of coastal and offshore stocks. Based on nuclear and mtDNA analysis, Lowther (2006) identified 5 haplotypes from 29 coastal animals and 25 haplotypes from 40 offshore animals in the southern California Bight. There were no shared haplotypes between coastal and offshore dolphins and significant genetic differentiation between the two ecotypes was evident.

Based on the geographical distribution of offshore bottlenose dolphin biopsy locations, Lowther (2006) further divided tissue samples into a northern and a southern group. Comparison of DNA structure between the northern and southern samples and with those collected at other locations in the North Pacific suggested structure among the offshore dolphins within the southern California Bight. Additional sampling across a wider geographic and temporal scale, as reported here, is needed to accurately assess the structure of this potentially highly divergent population

(Lowther 2006). Of particular interest in the present study is the assessment whther insular (i.e. island associated) population segments exist and if so, can they be genetically differentiated from pelagic and coastal forms of the species.

Risso's Dolphin Photo-Identification

The status of Risso's dolphins off California is not known and there are insufficient data to evaluate trends in abundance (Carretta et al. 2009). Abundance estimates ranging from 4,000 to 11,000 animals have been reported from five ship surveys conducted between 1991 and 2008 (Carretta et al. 2010). Inter-annual variation in the distribution of Risso's dolphin relative to ship survey area is likely responsible for differences in estimated abundance between surveys (Caretta et al. 2010). Without a clear understanding of Risso's dolphin population structure in the SOCAL region, it is difficult to develop and/or monitor abundance and survivorship estimates (Cardetta et al. 2009). To reliably assess the effects of sources of anthropogenic disturbance, such as MFAS, additional information on the population structure of Risso's dolphins is needed. The current photo-identification project as well as well as a first time DNA analysis will provide data to fill gaps in our understanding of Risso's dolphin population structure off southern California.

From August 2006 – July 2011, 69 groups of Risso's dolphins were photographed for individual identification at San Clemente Island, Catalina Island, and in the Gulf of Santa Catalina (Figure 7). Biopsy samples were also collected from six of the 69 groups encountered for a total of 12 tissue samples with corresponding individual photo-identifications. Analysis of the combined SIO/SWFSC and Cascadia Research Collective Risso's dolphin photographic database from August 2006 - July 2008 resulted in a catalog of 165 distinctive individuals from both San Clemente Island and Catalina Island.

Rate of Discovery

The rate at which individual Risso's dolphins were identified off San Clemente and Catalina Island from 2006-2008 was examined across surveys in which at least one dolphin was photographically identified (n=15 surveys, Figure 8). Rate of discovery, plotted as the cumulative number of newly identified individuals across each survey, indicates that new (i.e. previously unidentified) individuals were encountered throughout the three years analyzed to date. The consistent positive slope in the curve indicates that the population is larger than the current sample, with only 1 individual re-sighted during the three year period. In addition, the proportion of newly identified individuals ranged from 92% to 100% throughout the study indicating that on every survey where photo-identifications were acquired, all or most individuals had not been previously documented. This trend suggests that the overall population size for Risso's far exceeds the 165 individuals documented to date with a distribution that likely encompasses an area extending well beyond the San Clemente Island/Catalina Island complex. Analysis of data collected from 2008-2011 is currently underway which will allow for a more comprehensive analysis.

An investigation of Risso's dolphin stock structure, using DNA analysis, off Southern California is planned as is a broader comparison to samples collected at other locations in the North Pacific. Of particular interest in the present study is the assessment of whether insular (i.e. island associated) population segments exist off Southern California and if so, can they be genetically differentiated from pelagic and nearshore forms of the species.

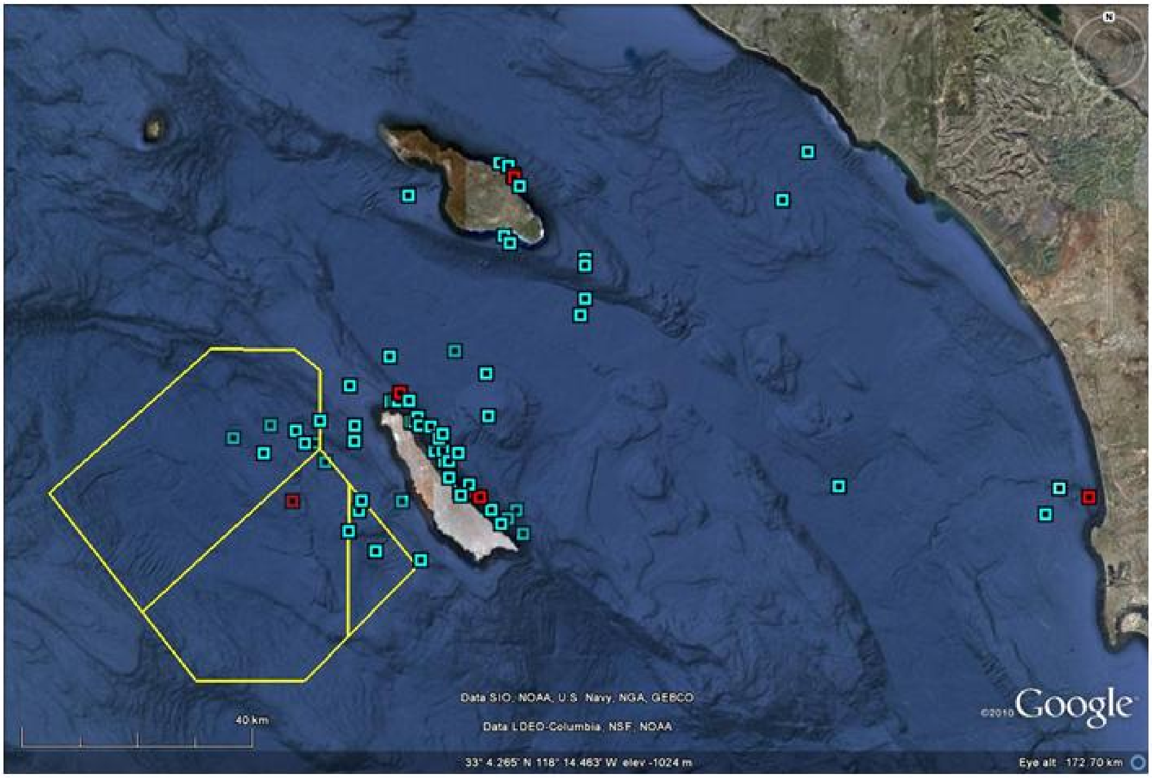

Figure 7. Distribution of Risso's dolphin sightings where at least one individual was photographically identified; Blue = Photo-ID only, Red = Biopsy and Photo-ID.

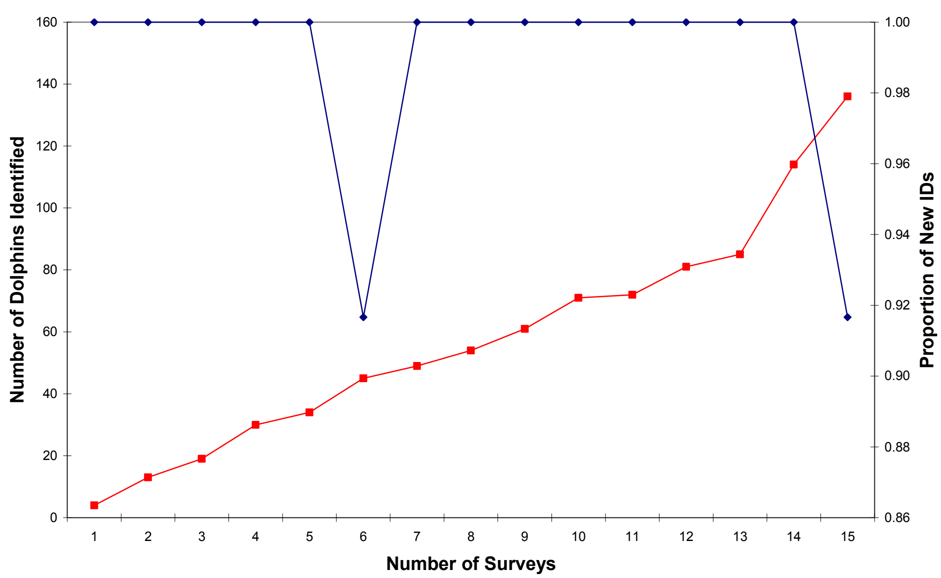

Figure 8. Cumulative number of Risso's dolphins (red) and proportion of new individuals photo-identified (blue) at San Clemente and Catalina Islands over 15 surveys in which at least one dolphin was identified. N = 136 individuals.

Pacific White-Sided Dolphin Biopsy and Acoustical Sampling

Genetic, morphometric and acoustical comparisons between Pacific white-sided dolphins in the southern California Bight indicate that two distinct stocks occupy the region. The northern California/Oregon/Washington stock occurs north of 33° N and the southern Baja California stock occurs south of 36° N, with overlap in the two stocks' ranges occurring between 33° and 36° N (Walker 1986, Lux *et al*. 1997, Caretta *et al*. 2009). Based on acoustical recordings of Pacific white-sided dolphin echolocation clicks in the southern California Bight, Soldevilla *et al*. (2010) identified two distinct spectral click structures (Type A and Type B) that were hypothesized to be stock-specific. In order to address the question of micro-geographic variation in click structure between the two northern and southern stocks, biopsy samples in conjunction with acoustical recordings of echolocation clicks have been collected on small vessel surveys from October 2008 to July 2011. Planned analyses will examine the genetic profile of the tissue sample relative to spectral click characteristics to assess potential correlates between call structure and stock structure.

From October 2008 to July 2011, seven groups of Pacific white-sided dolphins were acoustically recorded for click structure identification at Catalina Island, and off the San Diego coastline (Figure 9). Biopsy samples were also collected from six of the 69 groups encountered for a total of 12 tissue samples with corresponding individual photo-identifications.

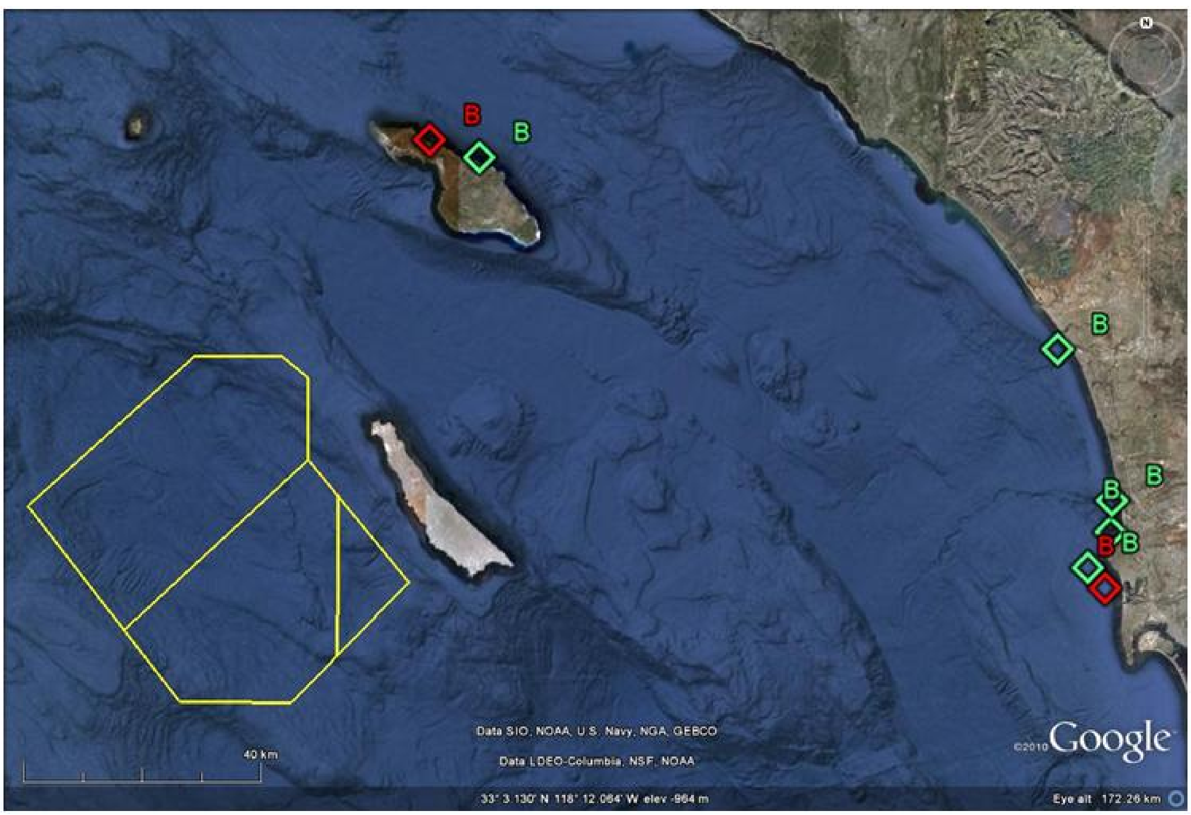

Figure 9. Distribution of Pacific White-Sided dolphin acoustical recordings from 2008-2011. Click type is denoted as Type A or Type B; Green = Acoustical Recording, Red = Biopsy and Acoustical Recording.

Acoustical Recordings

Acoustical recordings collected from October 2008 to July 2011 from the five delphinid species common to the SOCAL region have been incorporated into a larger database of cetacean acoustic data maintained at SIO. Several current projects are assessing clicks and/or whistles for species and population specific call structures that are essential for the interpretation of HARP long-term autonomous recordings conducted by SIO.

DISCUSSION

Sightings

Cetacean sightings across the three study areas during the 2010/2011 field season encompassed six odontocete and five mysticete species. Excluding common dolphins, bottlenose dolphins were the most commonly sighted species at Catalina Island and off the San Diego coastline while Risso's dolphins were the most frequently encountered cetacean at San Clemente Island. The distribution of cetacean species sighted off San Clemente Island was not uniform, with bottlenose and Risso's dolphin sightings mostly concentrated in near-shore waters. One-hundred percent of bottlenose and 75% of Risso's dolphin sightings occurred off the SOAR range with the remaining four sightings of this species occurring on the eastern portion of the range. Sightings of fin whales and Dall's porpoise around San Clemente Island were made exclusively on the SOAR range.

Photo-Identification

Photo-identification research to describe the occurrence, site fidelity, movement patterns and abundance of bottlenose and Risso's dolphins off San Clemente and Catalina Islands was highly successful, providing the first data of this type from the area. The catalogue of 419 distinctive individual bottlenose dolphins from San Clemente and 312 from Catalina, including 23 individuals identified off both islands, will provide the basis for deriving abundance estimates and residency patterns. Similarly, the 136 Risso's dolphins identified from 2006-2008 represent a first attempt to study this species in the waters off southern California. The current and future results regarding both of these species, by way of the research program described here, provide new information valuable to understanding their relationship (both spatial and temporal) to Navy activities off southern California.

Results of the bottlenose dolphin photo-identification studies from San Clemente and Catalina Island demonstrate a generally shallow water distribution and numerous within-year and between-year re-sightings in the two island complex. These trends suggest that at least some individuals in the population are island-associated in their distribution rather than part of an offshore population moving through the region. Additional sampling in the northern channel island complex will be valuable in determining whether the range of this population extends throughout the Channel Islands or is limited to the southern portion of the chain.

Additionally, photo-identification data from fin, blue and humpback whales were contributed to photographic catalogs maintained by Cascadia Research Collective.

To further assess temporal patterns of distribution for known bottlenose dolphins photographed at the two island sites, planned analysis will examine the occurrence of MFAS via HARP autonomous recordings simultaneous with documented sightings at the two island sites. These analyses will allow for a more detailed examination of potential geographic re-distribution relative to MFAS trials in the SCI region.

Biopsy Sampling

Bottlenose dolphin biopsies collected during offshore and coastal surveys provided samples for analyses along multiple metrics including stress and reproductive hormone levels, as well as genetic structure.

Samples collected around San Clemente and Catalina Island are currently being examined by Nick Kellar (SWFSC) for reproductive (progesterone) and stress (cortisol) hormone levels relative to MFAS exposure. Results of these analyses will be used to assess the relationship of these hormones to reproductive success. We plan to collect additional biopsies to allow for an assessment of GC concentration in the context of MFAS exposure. Our goal is to collect biopsies at San Clemente Island from 10-20 dolphins at three different times (i.e. conditions) relative to the Naval exercises: 1) approximately three to four weeks before exercises commence (pre-condition); 2) during the exercises, preferably 7-10 days post-commencement (during-condition); 3) approximately three to four weeks post-termination of the exercises (post-condition). Tissue samples collected during planned surveys at Catalina Island and the San Diego county coastline will also be assessed for GC concentrations with the coastal data providing a baseline index from a population having little to no exposure to MFAS. Biopsy samples will be paired with photo-identification images whenever possible to allow individual animals to be followed over both short (days, weeks, months) and long (years) time scales. HARP recordings acquired from the San Clemente Island region during biopsy sampling periods will be subsequently assessed for MFAS exposure metrics including duration, sound exposure levels and signal structure.

Planned DNA analyses will allow for an evaluation of population structure for bottlenose and Risso's dolphins in the SOCAL region, which will better define inshore versus offshore versus island-associated populations that are subject to different environmental and human related pressures. Higher resolution stock structure data will be pertinent in calculating mark-recapture population estimates for both species in offshore waters.

CONCLUSIONS

The primary objectives of the 2010/2011 SIO small boat based research program were to use sighting, photo-identification, biopsy and acoustical sampling techniques to assess the occurrence, distribution and population structure of small cetaceans in a region that is subject to frequent naval exercises. The results summarized in this report provide the framework for our multi-faceted approach to evaluating possible effects from MFAS trials.

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APPENDIX 1: SMALL BOAT SURVEY

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 08/13/10

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Marie Roch

The fifteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on August 13, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Seven hours of field effort covering 58 miles yielded sightings of two groups of bottlenose dolphins, one mixed group of short-beaked and long-beaked common dolphins, one group of long-beaked common dolphins and four groups of blue whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins and blue whales encountered. Acoustical recordings of whistles, clicks and buzzes were collected from bottlenose (*Tt1*) and common dolphins (*Dd/Dc1*). Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

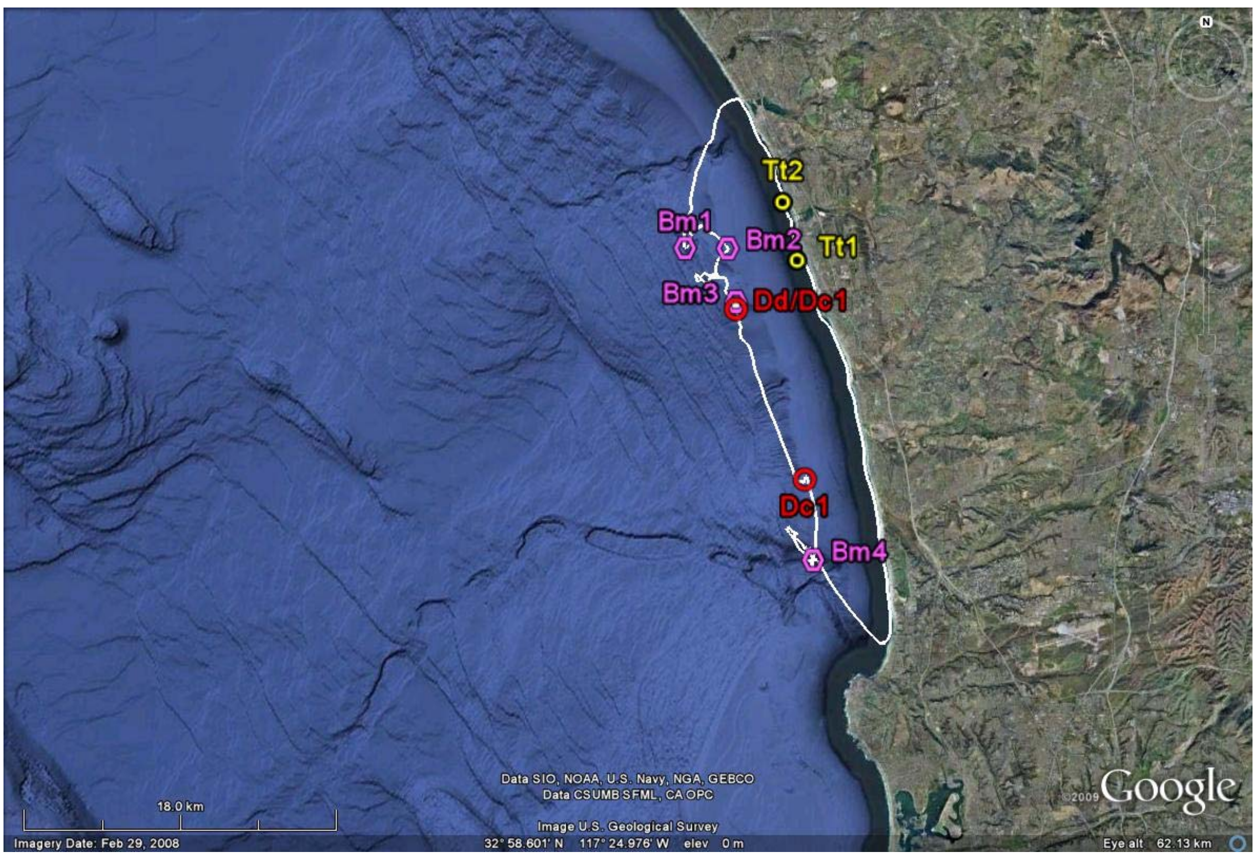

Figure 1. RHIB survey tracks and sighting locations for T. truncatus, D. delphis, D. capensis and B. musculus off the San Diego coastline, August 13, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, August 13, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	3	14	2	-
T. truncatus	Tt2	6	56	-	-
D. delphis / D. capensis	Dd/Dc1	85	4	2	-
D. capensis	Dc1	19	-	-	-
B. musculus	Bm1	3	47	-	-
B. musculus	Bm2	5	91	-	-
B. musculus	Bm3	5	149	-	-
B. musculus	Bm4	4	137	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 08/20/10

Crew: Greg Campbell, Sara Kerosky, Sara Pfeil, Lauren Williams

The sixteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on August 20, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Six hours of field effort covering 52 miles yielded sightings of two groups of long-beaked common dolphins, two mixed groups of short-beaked and long-beaked common dolphins, three blue whales and one unidentified baleen whale (Figure 1). This survey represents the first occasion during the current study where no coastal bottlenose dolphins were sighted. Photo-identification efforts produced high quality images from a large proportion of blue whales encountered and acoustical recordings of common dolphins (*Dd/Dc2*) yielded whistles, clicks and buzzes. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

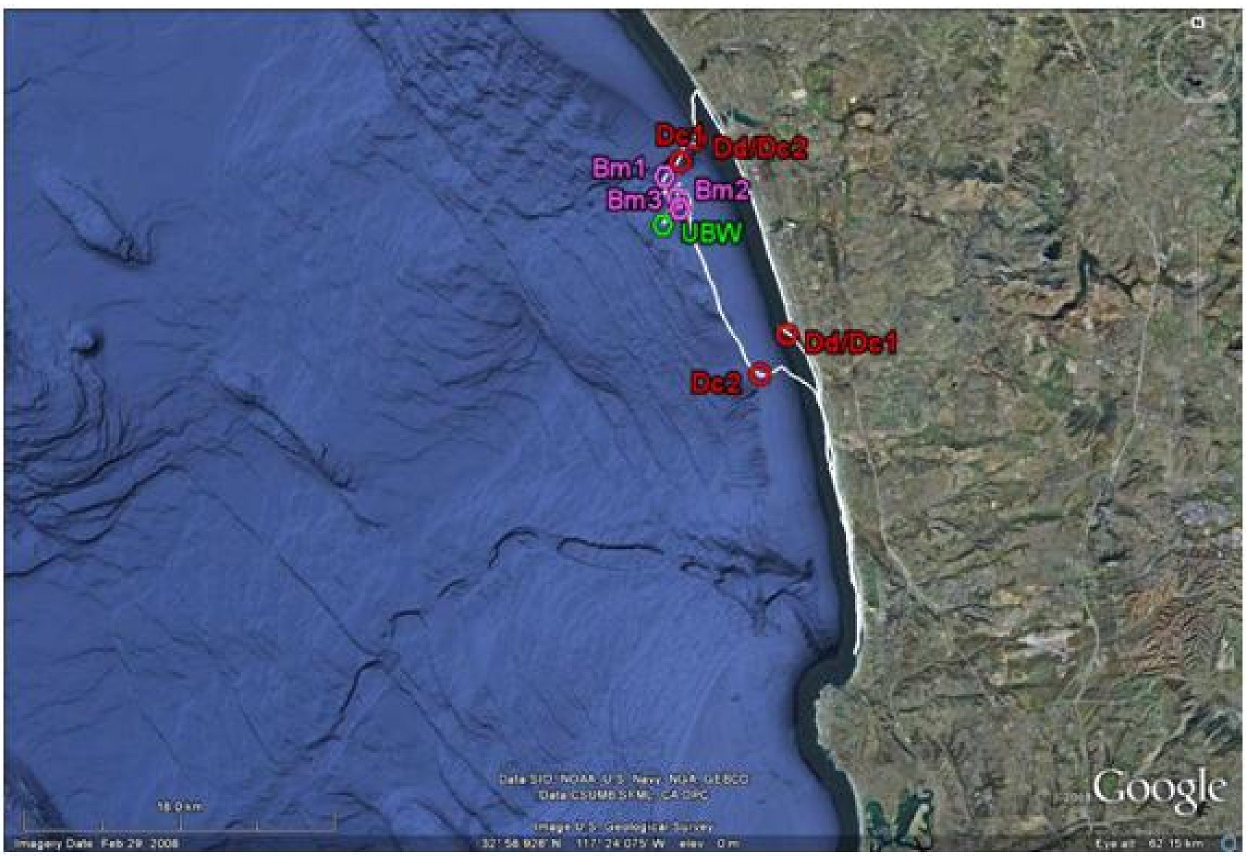

Figure 1. Survey tracks and sighting locations for D. delphis, D. capensis, B. musculus and an unidentified baleen whale off the San Diego coastline, August 20, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, August 20, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
D. delphis / D. capensis	Dd/Dc1	56	-	-	-
D. delphis / D. capensis	Dd/Dc2	140	5	1	-
D. capensis	Dc1	35	-	-	-
B. musculus	Bm1	1	26	-	-
B. musculus	Bm2	1	19	-	-
B. musculus	Bm3	1	75	-	-
Unid bakeen whale	UBW	1	16	-	-
D. capensis	Dc2	52	18	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 09/14/10

Crew: Greg Campbell, Dave Weller, Tyler Helble, Mary Grady

The seventeenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on September 14, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Six hours of field effort covering 45 miles yielded sightings of five groups of bottlenose dolphins, one group of long-beaked common dolphins and one group short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of coastal bottlenose dolphins (*Tt*5) yielded no vocalizations; however, snapping shrimp created a marginal signal/noise ratio. One biopsy sample was collected from coastal bottlenose dolphins for an assessment of stress hormones and microbiological contaminants. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus, D. capensis and D. delphis off the San Diego coastline, September 14, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, September 14, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	2	21	-	-
T. truncatus	Tt2	3	88	-	1
T. truncatus	Tt3	5	170	-	-
T. truncatus	Tt4	7	174	-	-
T. truncatus	Tt5	3	25	2	-
D. capensis	Dc1	1206	8	-	-
D. delphis	Dd1	424	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 09/30/10

Crew: Greg Campbell, Dave Weller, Martin Gassman, Alex Kesaris

The eighteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on September 30, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

The survey was truncated due to steering problems with our RHIB; however, one hour of field effort covering 4 miles yielded a sighting of one group of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from the two bottlenose dolphins encountered. Upon completion of photographic data collection, we returned to Scripps Pier for boat repairs. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

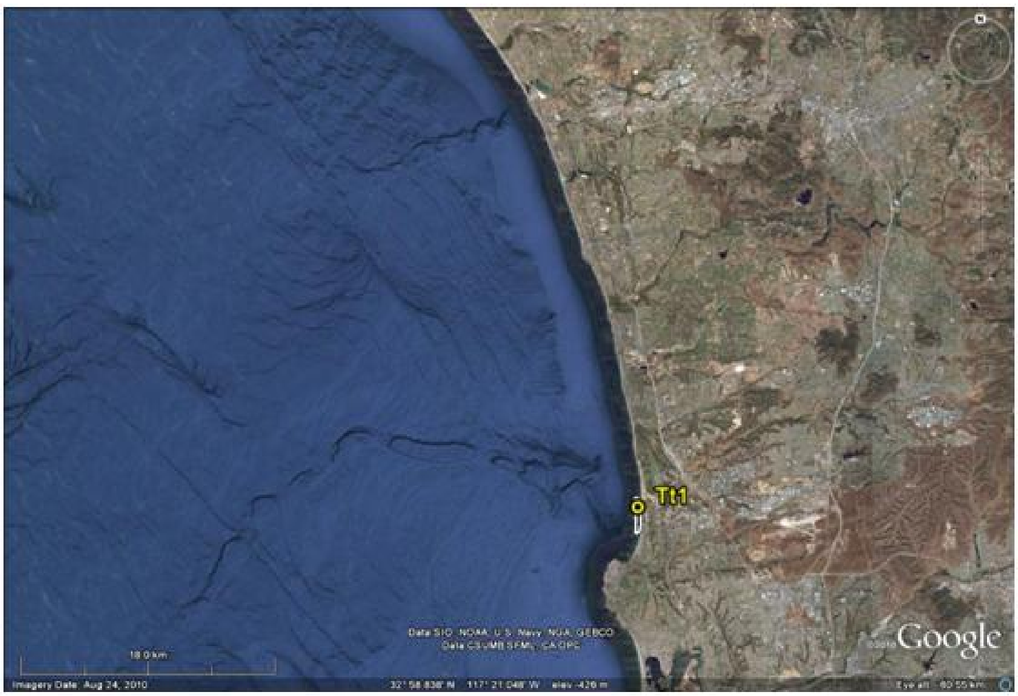

Figure 1. Survey tracks and sighting location for T. truncatus off the San Diego coastline, September 30, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, September 30, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	2	6	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 10/14/10

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Martin Gassman, Alex Kesaris

The nineteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on October 14, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 53 miles yielded sightings of three groups of bottlenose dolphins, two groups of long-beaked common dolphins, one mixed group of long-beaked and short-beaked common dolphins and one mixed group of Risso's and bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose and Risso's dolphins encountered. Acoustical recordings of common dolphins (*Dd/Dc1*) yielded clicks, buzzes and whistles. Three biopsy samples were collected from Risso's dolphins for an assessment of regional stock structure. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus, G. griseus, D. capensis and D. delphis off the San Diego coastline, October 14, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, October 14, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	4	21	-	-
T. truncatus	Tt2	3	19	-	-
T. truncatus	Tt3	10	208	-	-
T. truncatus/G. griseus	Tt/Gg1	12/14	307	-	3 (Gg)
D. delphis/D. capensis	Dd/Dc1	375	-	4	-
D. capensis	Dc1	14	-	-	-
D. capensis	Dc2	237	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 10/21/10

Crew: Greg Campbell, Dave Weller, John Hurwitz, Matt Leslie

The twentieth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on October 21, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 53 miles yielded sightings of five groups of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable and unpredictable dolphin movement patterns precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus off the San Diego coastline, October 21, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, October 21, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	3	27	-	-
T. truncatus	Tt2	1	5	-	-
T. truncatus	Tt3	3	39	-	-
T. truncatus	Tt4	5	75	-	-
T. truncatus	Tt5	10	154	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 11/11/10

Crew: Greg Campbell, Dave Weller, Sara Kerosky

The twenty-first in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 11, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Four hours of field effort covering 19 miles yielded sightings of four groups of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable and unpredictable dolphin movement patterns precluded the collection of acoustical data and biopsy samples. Increasing swell and wind led to the termination of our efforts before the survey was completed. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus *off the San Diego coastline, November 11, 2010.*

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 11, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	23	84	-	-
T. truncatus	Tt2	20	128	-	-
T. truncatus	Tt3	9	107	-	-
T. truncatus	Tt4	12	60	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 11/16/10

Crew: Greg Campbell, Dave Weller, Alex Kesaris

The twenty-second in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 16, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 47 miles yielded sightings of three groups of bottlenose dolphins and one group of short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable and unpredictable dolphin movement patterns precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus and D. delphis off the San Diego coastline, November 16, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 16, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	10	259	-	-
T. truncatus	Tt2	27	518	-	-
T. truncatus	Tt3	9	144	-	-
D. delphis	Dd1	2122	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 11/30/10

Crew: Greg Campbell, Sara Kerosky, Lauren Roche

The twenty-third in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 30, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 57 miles yielded sightings of four groups of bottlenose dolphins and one mixed group of short-beaked and long-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of bottlenose dolphins yielded echolocation clicks and whistles. Variable dolphin movement patterns precluded the collection of biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus and D. delphis/D. capensis off the San Diego coastline, November 30, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 30, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	12	395	4	-
T. truncatus	Tt2	23	361	-	-
T. truncatus	Tt3	12	92	1	-
T. truncatus	Tt4	8	72	-	-
D. delphis/D. capensis	Dd/Dc1	820	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 12/17/10

Crew: Greg Campbell, Dave Weller, Lauren Roche

The twenty-fourth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on December 17, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Four hours of field effort covering 42 miles yielded sightings of two groups of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable dolphin movement patterns and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus off the San Diego coastline, December 17, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, December 17, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	36	393	-	-
T. truncatus	Tt2	4	51	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 01/20/11

Crew: Greg Campbell, Dave Weller, Alex Kesaris

The twenty-fifth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 20, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 54 miles yielded sightings of 10 groups of bottlenose dolphins, one group of Pacific white-sided dolphins and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. The sheer volume of animals that required photo-identification and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

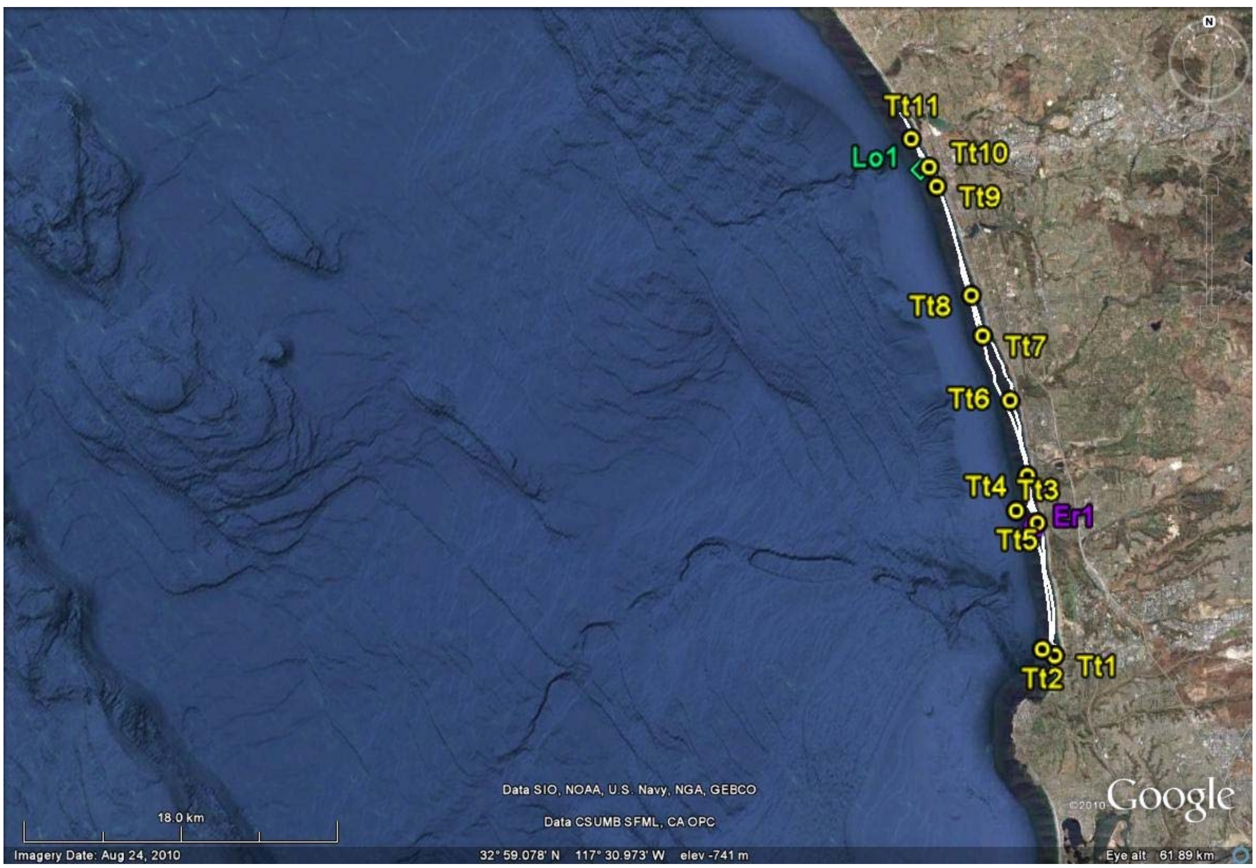

Figure 1. Survey tracks and sighting locations for T. truncatus, L. obliquedens and E. robustus off the San Diego coastline, January 20, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 20, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	13	44	-	-
T. truncatus	Tt2	17	58	-	-
T. truncatus	Tt3	12	74	-	-
T. truncatus	Tt4	2	14	-	-
T. truncatus	Tt5	3	18	-	-
T. truncatus	Tt6	5	35	-	-
T. truncatus	Tt7	7	65	-	-
T. truncatus	Tt8	9	32	-	-
T. truncatus	Tt9	5	48	-	-
T. truncatus	Tt10	4	29	-	-
T. truncatus	Tt11	5	21	-	-
L. obliquedens	Lo1	7	-	-	-
E. robustus	Er1	1	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 01/27/11

Crew: Greg Campbell, Amanda Cummins, Alex Kesaris

The twenty-sixth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 27, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 54 miles yielded sightings of four groups of bottlenose dolphins, one group of Pacific white-sided dolphins, two groups of common dolphins and two grey whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable dolphin movement patterns and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus, L. obliquedens, D. delphis, D capensis and E. robustus off the San Diego coastline, January 27, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 27, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	30	215	-	-
T. truncatus	Tt2	7	23	-	-
T. truncatus	Tt3	2	11	-	-
T. truncatus	Tt4	9	23	-	-
L. obliquedens	Lo1	8	4	-	-
D. delphis/D. capensis	Dd/Dc1	50	5	-	-
D. Spp	Dspp1	41	-	-	-
E. robustus	Er1	1	1	-	-
E. robustus	Er2	1	2	-	-

CALIFORNIA COASTAL SAN DIEGO SURVEY – 02/14/11

Crew: Greg Campbell, Amanda Cummins, Sara Kerosky

A small boat cetacean survey concurrent with an aerial survey off the San Diego county coastline was conducted on February 14, 2011. The primary objectives were to use both observation platforms to increase the probability of detection for cetacean species in the region and to confirm species ID and group size estimates.

Seven hours of field effort covering 43 miles yielded sightings of one group of bottlenose dolphins, one group of common dolphins and one unidentified baleen whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

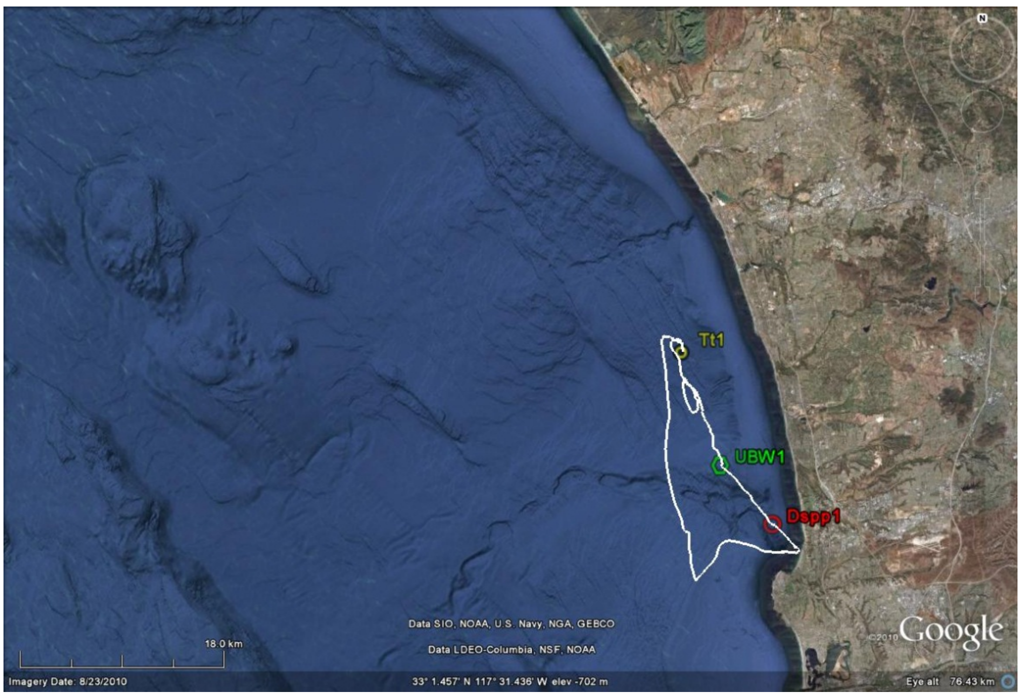

Figure 1. Survey tracks and sighting locations for T. truncatus, D. spp and an unidentified baleen whale off the San Diego coastline, February 14, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 14, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	6	29	-	-
D. spp	Dspp1	12	-	-	-
Unid Baleen Whale	UBW1	9	14	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 02/15/11

Crew: Greg Campbell, Amanda Cummins, Liz Henderson, Alex Kesaris

The twenty-seventh in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 15, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 66 miles yielded sightings of 9 groups of bottlenose dolphins, two groups of short-beaked common dolphins and two grey whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. The sheer volume of animals that required photo-identification and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

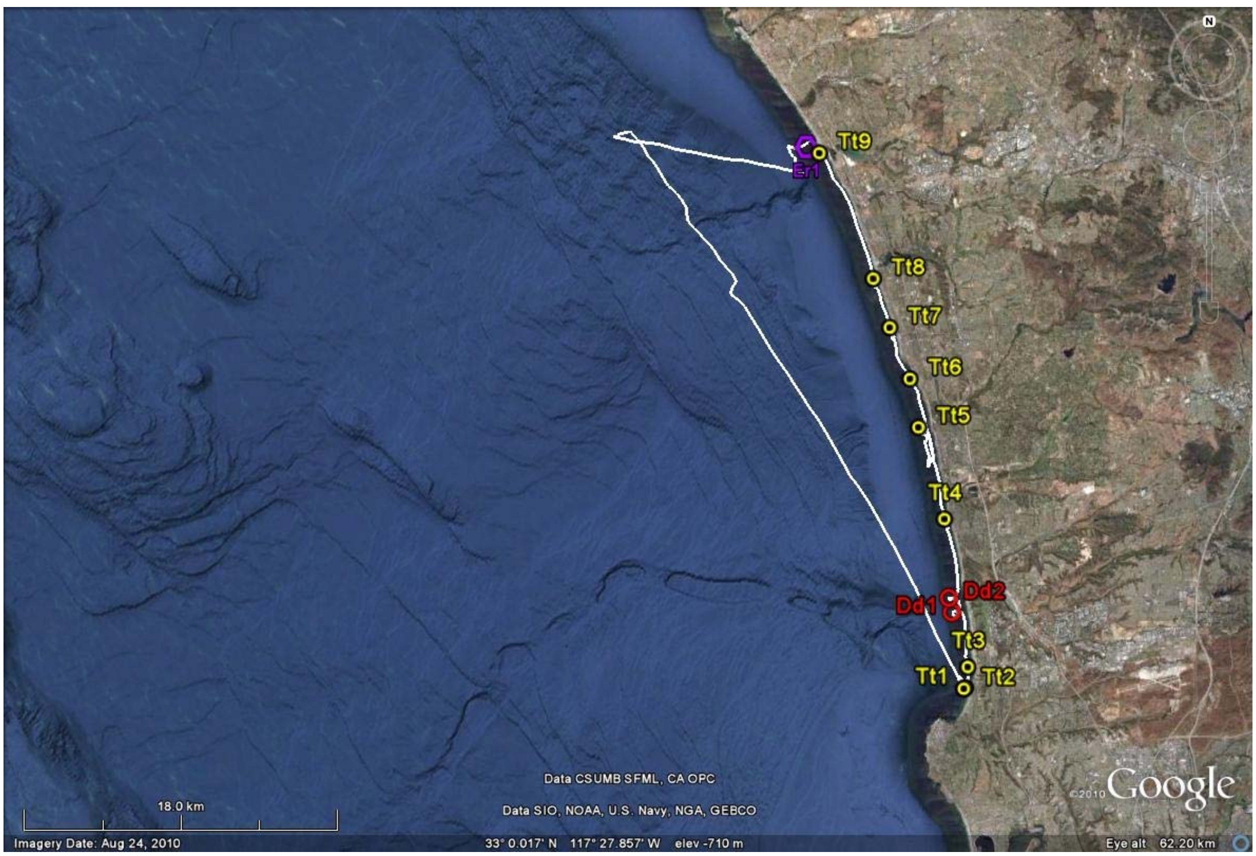

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis and E. robustus off the San Diego coastline, February 15, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 15, 2011

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	15	-	-	-
T. truncatus	Tt2	20	98	-	-
T. truncatus	Tt3	9	67	-	-
T. truncatus	Tt4	8	25	-	-
T. truncatus	Tt5	10	124	-	-
T. truncatus	Tt6	3	54	-	-
T. truncatus	Tt7	18	276	-	-
T. truncatus	Tt8	6	86	-	-
T. truncatus	Tt9	10	68	-	-
D. delphis	Dd1	38	-	-	-
D. delphis	Dd2	300	-	-	-
E. robustus	Er1	2	19	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 02/22/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins

The twenty-eighth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 22, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 50 miles yielded sightings of two groups of bottlenose dolphins, one group of Pacific white-sided dolphins, and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. One biopsy sample was collected from Pacific white-sided dolphins but the school was lost prior to acoustical data collection. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

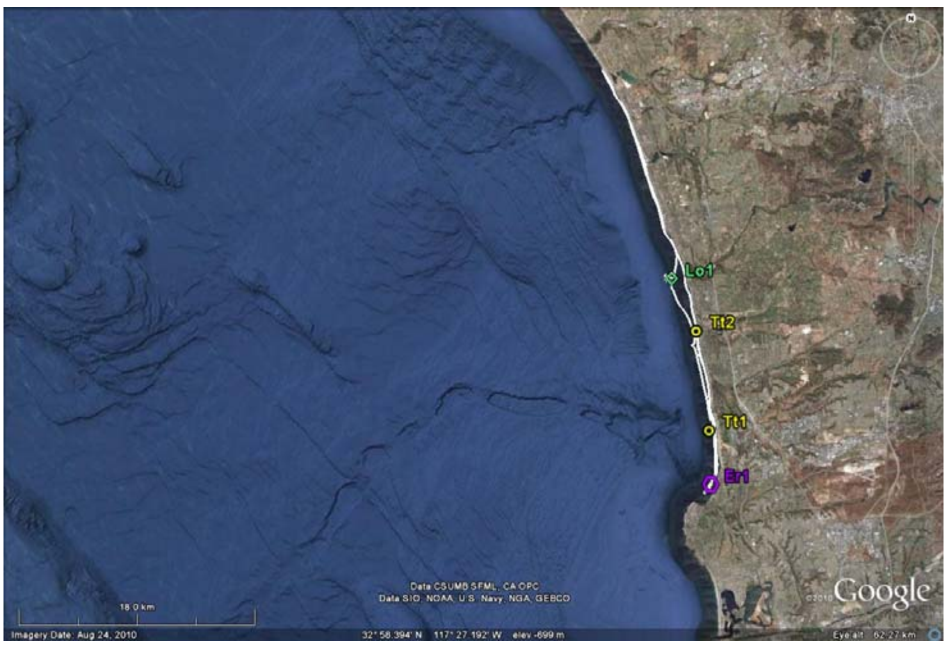

Figure 1. Survey tracks and sighting locations for T. truncatus, L. obliquedens and E. robustus off the San Diego coastline, February 22, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 22, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	17	305	-	-
T. truncatus	Tt2	20	286	-	-
L. obliquedens	Lo1	11	75	-	1
E. robustus	Er1	1	11	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 03/16/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins

The twenty-eighth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 16, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 49 miles yielded sightings of five groups of bottlenose dolphins and one group of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Large swell and variable dolphin movement patterns precluded the collection of biopsy and acoustical data. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus and L. obliquedens and off the San Diego coastline, March 16, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 16, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	15	263	-	-
T. truncatus	Tt2	8	94	-	-
T. truncatus	Tt3	2	7	-	-
T. truncatus	Tt4	3	19	-	-
T. truncatus	Tt5	4	9	-	-
L. obliquedens	Lo1	3	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 03/23/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Kait Frasier

The twenty-ninth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 23, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 49 miles yielded sightings of four groups of bottlenose dolphins and one group of long-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of bottlenose dolphins (Tt1) yielded high-quality whistles, clicks and buzzes. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis/D. capensis and E. robustus off the San Diego coastline, March 23, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 23, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	26	198	3	-
T. truncatus	Tt2	5	32	-	-
T. truncatus	Tt3	10	110	-	-
T. truncatus	Tt4	9	42	-	-
D. capensis	Dc1	52	17	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 04/19/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Alex Kesaris

The thirtieth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on April 19, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 59 miles yielded sightings of 10 groups of bottlenose dolphins, one mixed group of short and long-beaked common dolphins and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. The survey included a noteworthy observation (Tt6) of a mom carrying her dead calf across the front edge of her dorsal fin. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

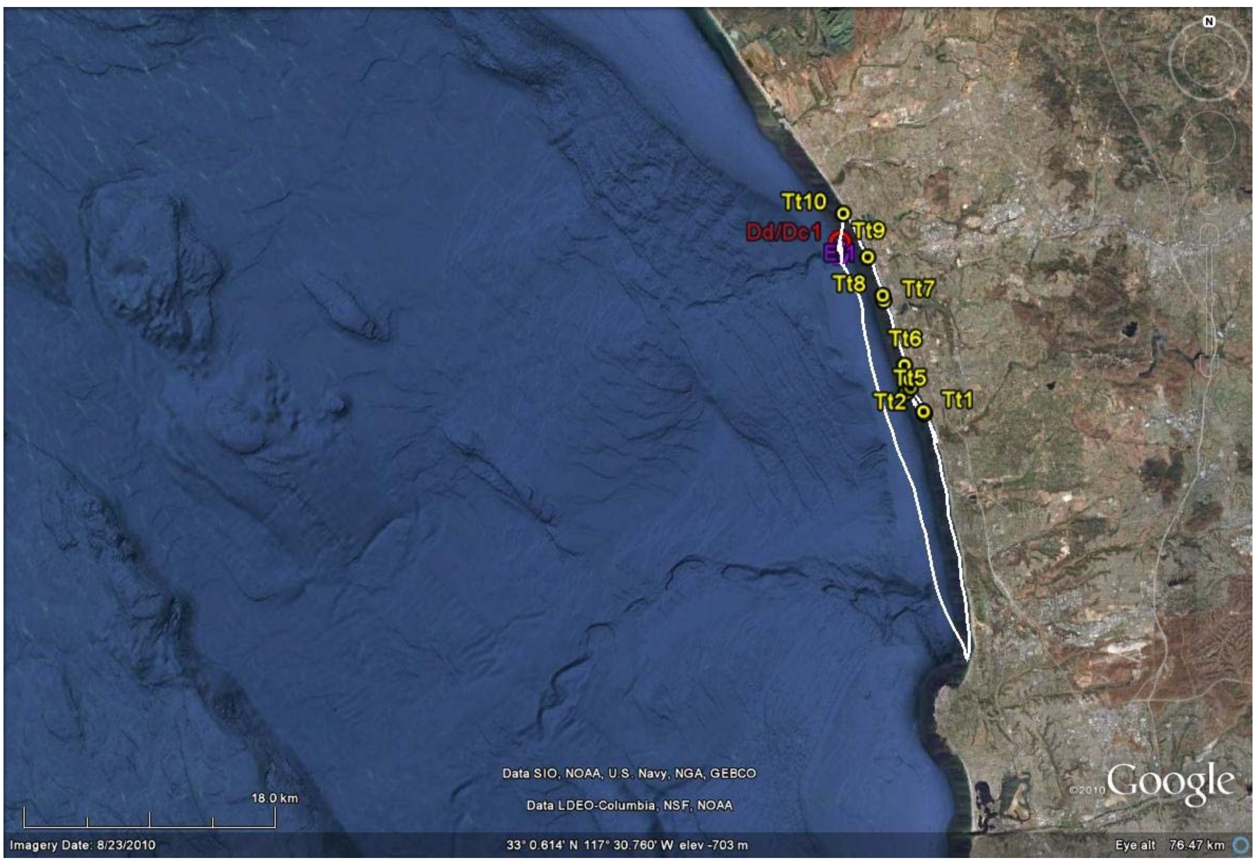

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis/D. capensis and E. robustus off the San Diego coastline, April 19, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, April 19, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	12	199	-	-
T. truncatus	Tt2	6	42	-	-
T. truncatus	Tt3	2	22	-	-
T. truncatus	Tt4	5	21	-	-
T. truncatus	Tt5	4	20	-	-
T. truncatus	Tt6	5	61	2	-
T. truncatus	Tt7	2	11	-	-
T. truncatus	Tt8	3	12	-	-
T. truncatus	Tt9	8	46	-	-
T. truncatus	Tt10	2	7	-	-
E. robustus	Er1	1	1	-	-
D. delphis/ D. capensis	Dd/Dc1	640	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 07/07/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Alex Kesaris

The thirty-third in a series of small boat cetacean surveys off the San Diego county coastline was conducted on July 7, 2011. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 52 miles yielded sightings of four groups of bottlenose dolphins, one group of short-beaked common dolphins, two groups of unidentified common dolphins and three groups of blue whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins and blue whales encountered. The survey included a noteworthy observation (Bm3) of a blue whale with distinct propeller scars, which has been submitted to the NMFS regional office. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis/D. capensis and E. robustus off the San Diego coastline, July 7, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, July 7, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	27	113	-	-
T. truncatus	Tt2	8	45	1	-
T. truncatus	Tt3	7	35	-	-
T. truncatus	Tt4	1	4	-	-
B. musculus	Bm1	1	28	-	-
B. musculus	Bm2	1	21	-	-
B. musculus	Bm3	1	32	-	-
Delphinus spp	Dspp1	10	-	-	-
Delphinus spp	Dspp2	6	-	-	-
D. delphis	Dd1	750	-	-	-